NEW ENGLAND WATER WORKS ASSOCIATION.

ORGANIZED 1882.

Vol. I. Sept. 1886. No. 1.

This Association, as a Body, is not responsible for statements or opinions of any of its members.

PROCEEDINGS OF THE FIFTH ANNUAL CONVENTION.

New Bedford, June 16, 1886.

The New England Water Works Association assembled in its Fifth Annual Convention at the Odd Fellows Hall in this city at 4 p. m., the President, Robert C. P. Coggeshall, of New Bedford in the chair. The Hon. Morgan Rotch, Mayor of the city, was presented to the convention, and he spoke as follows:

ADDRESS OF WELCOME BY MAYOR ROTCH.

Gentlemen of the New England Water Works Association:—It gives me great pleasure as chief magistrate of this city to bid you a hearty and cordial welcome, not only as guests worthy of an honorable reception for your own achievements in the various walks of scientific research, but also as guests from whose presence here some special good may come to us. Among the many blessings which in ancient and modern times have come to the world, may perhaps be reckoned as one of the greatest the introduction of water into the large cities and towns, so that all the people, high and low, rich and poor, may be able to use freely this great preserver of the public health. At considerable cost, and certainly with great care and industry on the part of the men who first conceived and executed the plans, we have brought water into our city, and, as you may perhaps be aware, have distributed it more freely and at less cost to the people than has almost any other city or town in the country. Our superintendent, Mr. Coggeshall, will, I doubt not, take great pleasure in showing you all that we have to show, and in making everything appertaining to his charge appear as well as possible.

Now, gentlemen, I do not suppose that you are invested with more than mortal insight, that you can see things which the mortal eye cannot see, or comprehend things which the mind of man is incapable of comprehending. But I remember well that when a boy I had a strong conviction that if I should chance to stand in the presence of a great physician and he looked at me and said nothing, that my constitution was all right. In other words, I believed that if there was anything the matter with me he would instantly know it, and feel it his duty to tell me so. Now I need hardly say that as the years have gone by, my boyish faith in the great

physician has somewhat weakened. But nevertheless, I have a kind of faith, born perhaps of that boyish feeling, that as you go about our city looking at our pumping engines, our reservoirs and our methods of distributing water, if there is anything wrong about them you will certainly see it and feel it to be your duty to tell us of it. Pardon me, gentlemen, then, if in this cordial reception there seems to mingle something of this selfish feeling; but let me assure you that whatever the sequel may be, whether it shall turn out that while you are here you may, like the good physician, feel it to be your duty to approve or disapprove, to censure or to praise, we shall all feel a new sense of security in your coming, and unite in wishing that your visit among us may be so pleasant as to induce you to make many and frequent returns.

In response to the Mayor's address President Coggeshall spoke as follows:

Mr. Mayor, In behalf of the New England Water Works Association I thank you most heartily for your cordial welcome. I am glad to know that our association and the work that it represents is commended by you; and I cordially invite you and all members of your city government to take seats with us and participate in the programme which is about to follow. (Applause.)

The convention then proceeded to business.

ELECTION OF NEW MEMBERS.

The Secretary then read the following names of applicants for membership, which he stated had been considered by the Executive Committee, who had voted to recommend them for admission to the association.

APPLICANTS FOR MEMBERSHIP.

ACTIVE.

William E. Nason, superintendent, Franklin, Mass.
William Ripley Nichols, professor chemistry, Boston, Mass.
W. S. Chaplin, professor engineering, Harvard University.
W. H. Whitcomb, president water company, Norway, Me.
Martin Coryell, engineer and superintendent, Lambertville, N. J.
Charles B. Brush, engineer and superintendent, Hoboken, N. J.
Edward H. Phipps, hydraulic engineer and superintendent, New Haven.
Robert L. Cochran, superintendent, Nahant.
Charles H. Nettleton, agent and superintendent, Birmingham, Conn.
George P. Westcott, treasurer water company, Portland, Me.
A. S. Frierson, superintendent and engineer, Columbus, Miss.
Patrick Kieran, superintendent, Fall River.
Francis A. Dewson, commissioner, Newton.
Harry C. Heermans, superintendent, Corning, N. Y.
Nathan C. Bickford, superintendent water works O. C. R. R., Boston.
James P. Wigal, superintendent, Henderson, Ky.
V. C. Hastings, superintendent, Concord, N. H.
John M. Diven, secretary and treasurer, Elmira, N. Y.
James Wilson, engineer, Kingston, Ca.
Edward Heywood Brown, secretary, treasurer, superintendent, Syracuse, N. Y.
William Ryle, superintendent, Patterson, N. J.

A. W. Denman, secretary and manager, Des Moines, Ia.
M. L. Holman, assistant engineer, St. Louis, Mo.
Stephen E. Babcock, chief engineer, Little Falls, N. Y.
Frank L. Fuller, engineer, Wellesley Hills, Mass.
David B. Kempton, commissioner, New Bedford.
Joseph E. Beals, clerk and registrar, Middleboro.
Charles F. Allen, treasurer, Hyde Park.
Walter Coburn, president, Lowell.
William Dixon, superintendent, Mt. Pleasant, Mich.
W. P. Whittemore, superintendent, North Attleboro.

ASSOCIATE.

W. C. McClennan, contractor, Boston.
Z. E. Coffin, manufacturer supplies, Neponset, Mass.
J. A. Tilden, Hersey Meter Company, Hyde Park, Mass.

On motion of Mr. Hyde, the Secretary was directed to cast the ballot of the association for the admission of the gentlemen whose names had just been read. The Secretary did so and the President announced their election.

PRESIDENT'S ADDRESS.

Gentlemen of the New England Water Works Association:—By a provision of our constitution it becomes the duty of the President to address this Association at the opening of each annual convention upon matters pertaining to its welfare.

Let us briefly consider the growth of our society. It was in the month of April. 1882, that twenty-one gentlemen, all managers of different water departments, assembled in the city of Boston to consider their wisdom of organizing such a society as we of this Association to-day represent. Although this assemblage was small in numbers yet much enthusiasm was aroused. As the result a committee was appointed to draft a constitution which was adopted, and the Association was fairly launched into being on the 21st of June, 1882, with a membership of twenty-seven, all active members. The fall meeting of that year was held at Salem, and on assembling at Worcester at the completion of our first year we recorded a total membership of forty-three. Very modest were our ideas then regarding the future growth of our society, for I remember we then thought that number to be a good showing for the first year. Our second field day gathering was at Pawtucket, and the convention at Lowell at the end of our second year found us with a total membership of fifty-seven, forty-eight of this number being active members. During the third year of our existence four meetings were held instead of two, as in previous years, one of these being the memorable convention with the American Water Works Association at Boston in April of last year. At this time we received large additions to our ranks and at the Springfield convention a year since we recorded a total membership of one hundred and twenty-four, and of this number eighty-three were active members.

While the past year has not been distinguished by any gathering as brilliant as that with the American Water Works Association which occurred in Boston, April, 1885, yet there have been a larger number of meetings in the name of the Association than in any previous year. The meetings

have all been well attended and the interest of the members has been fully maintained. There have been, as you are aware, five meetings exclusive of the annual convention at Springfield last June, the first being the field day gathering at South Framingham, the remainder being the series of informal gatherings at Boston since the first of the present year. The attendance, including members with their invited guests was forty-two, forty, thirty-one, fifty-five and thirty-three respectively. Our total membership, including those just elected is one hundred and eighty-seven, and of this number one hundred and thirty-seven are active members, and fifty associate members.

The membership of this Association at present probably represents about forty per cent. of the total number of water departments and companies of New England, and certainly includes most of those of any considerable size. There is every reason to hope that, later, we shall count the entire list in our fold. This can only be accomplished by proving to them that they, not we, are the losers in being outside our ranks.

Considered as a whole, I think we have good reason to congratulate ourselves on the progress we have made and on the success which has attended our efforts up to the present time, and, as an Association, we should, I think, consider ourselves fairly equipped to do excellent service for the cause in which we are enlisted.

The marked success attendant on the series of informal monthly gatherings which lately occurred would seem to indicate that the continuance of such a series the coming year must result in still greater good. There can be no better way with less loss of time, for the different members to become thoroughly acquainted with each other's methods than through the instrumentality of these informal gatherings.

The committee to whom was assigned the work of revising the constitution have, as you are aware, completed their task, and each of you has received the result of their labors in printed forms. Their recommeudations have the indorsement of the executive committee.

In the report as presented there is one portion to which I would call your attention especially, viz: Article V. Section 1, and Article VI. Section 4, which provided for the appointment of a Board of Editors who shall prepare for publication the transactions of this Association. Two reasons present themselves for the appointment of such a Board. First. the including of so much of the detail of the discussions necessarily compels the issue of a bulky pamphlet which in itself is expensive. Second, in the discussion which follows the readiug of a paper many casual statements are apt to be made without much thought on the part of the speaker. Perhaps some simple question asked, some trifling occurrence mentioned, all very well and highly appropriate at the time the words were spoken but which the speaker would not care to have set down as an expression of his deliberate thought.

I would not have my remarks interpreted as being in any sense a criticism upon the past work of our Secretary. Not being vested with the power in regard to the revision of the stenographer's reports of our meetings he could not do otherwise than he has done.

In considering the future it seems proper to offer a few suggestions at this time. It has occurred to me that it would not be a bad idea to de-

vote the time alloted to informal discussions at one or two of our future gatherings to a recital of errors. Each member would be expected to give an account of some mistake or mishap which had occurred in his practice. It is entirely human to err and we are not apt to say much concerning our failures, yet experience often teaches that more is to be learned by the candid avowal of a mistake and the discussion which such a statement would bring forth than by the relating of something which is a pronounced success. When we consider the good feelings which have always prevailed at our gatherings, it would, I am sure, be a sufficient guarantee of the spirit with which statements of this kind would be received and discussed.

We all agree that the discussions that follow the reading of a paper should be made the most profitable part of the exercises of a society such as ours. I would call your attention to a method already adopted by some organizations. In this method a complete abstract of the subject matter in each paper is drawn off, and sent to each member at least a month previous to the convention. This provides those who desire it with the line of thought which the paper contains, and the member is thus enabled to prepare himself to take part in the discussion previous to its occurrence. If he is so inclined he can present his discussion in writing.

And this leads me to say that I think it would be well to provide that all papers to be presented to the Annual Convention, should be in the possession of the Secretary at least two months previous to the time of that gathering. This would be necessary in order to carry into effect the previous suggestion, and it would also give your committee a fair chance to provide a good substitute for any one who should fail to present his paper.

I confess to a fondness for examining results tabulated in graphical form. Any information thus expressed has a greater value to the average worker than if shown in any other way. At a glance one is able to comprehend more, to compare results with a better understanding, to more rapidly analyze the whole subject matter under consideration, than by any other way. The work of to-day is done with a rush. We can hardly spare time to eat and sleep. In order to command a hearing on any subject from the busy people of this age one must place his ideas in terms direct, forcible and concise. Expression made in a graphical form, is conciseness carried to its utmost limit. Many of us will willingly testify to the value of such work as has appeared in our past transactions, such as Mr. Sherman's diagram for ascertaining the duties of pumping engines, our secretary's compilation of information relative to service pipes, and Mr. Noye's elaborate tabulation of statistics relative to the weights of cast-iron pipe. It would be well if there were more attempts made to give information relative to various subjects in this form.

I wish to add a few words at this time relative to a topic which was considered by you at the last Annual Convention. I refer to the paper prepared and presented by Mr. Billings and myself on "Uniformity in the preparation of the Annual Report." At the time it was presented this scheme seemed to meet with your hearty endorsement and recommendation, yet of the reports issued the past year the plan has been adopted and carried into effect in the following places only, Burlington, Vt.,

New London, Conn., New Orleans, La., Woonsocket and Pawtucket, R. I., and Springfield, Newton, Worcester, Holyoke, Taunton and New Bedford, Mass. In some of these places the scheme was most carefully followed, in others the attempt will be found far from satisfactory to those who may wish to compare results in two or more places. I trust the reason so few adopted this plan may be explained by the delay which occurred in the delivery of the transactions in which the instructions and descriptions of the plan were included.

The ENGINEERING NEWS in a recent editorial advocates the passage of a State law compelling all water supply companies to formulate their statistics on a uniform basis. This article presents the following conclusions: "That there is a vast amount of capital invested in water supply companies which is constantly being increased by the addition of new plants or the extension of those already in existence.

"That the relation of a water supply company to the general public is of the most intimate character and in consequence all classes are thoroughly interested in their welfare and should know something as to their internal management.

"That a large number of corporations such as railroads, banks, insurance, manufacturing, are required by law to make an exhibit which shall be accessible to all desiring such information.

"And the query arises why the law is not extended to include corporations supplying so essential a necessity as water."

Not only would such a law be of service in aiding us to obtain a statement of the actual condition of affairs in "private companies" but it would compel a systematic statement from many larger places where the reports as presented to-day are altogether too obscure.

In examining the list of summaries which have appeared in the reports of various departments for the past year as before stated, I find none more complete and in full accord with the plan than those from Burlington, Vt., Woonsocket, R. I., and New London, Conn., the superintendents of which have given fine examples of what may be easily accomplished by each of us. They apparently have not experienced any particular difficulty in arriving at the desired results, and why should any of us? That it will require extra labor to obtain these facts there is no doubt, but of course each of us expects to do his share. I hope you will not consider me over zealous in this matter but I wish each member would agree, if it is in the range of possibility, to see to it, that this "summary" appears in the very next report which is issued by the department under his charge. Will you not give this your earnest consideration and all agree to give it a fair trial the coming year, so that at our next meeting it will be possible to place before you the comparative statistics of the many departments represented here to-day? In no other way can we ascertain the merits or defects which the plan may possess.

A matter that has been the cause of considerable care to our Executive Committee in the past has been the selection and assignment of topics for discussion. Not that there is any difficulty in our profession in finding an abundance of topics; on the contrary there are so many that the trouble has been to select those of the greatest interest to the greatest number. The new constitution, if adopted, will provide for the assignment of top-

ics by the Board of Editors and I earnestly recommend that our members freely suggest to them any subject which may occur to them upon which a paper and discussion would be of interest and benefit. In this way I feel that the work of our officers may be lightened and the objects of our Association materially promoted.

And, finally, is there not something to be gained by assembling in gatherings like this aside from the business and the discussions? Is it not well for us to occasionally move outside of the mere routine into which our daily thoughts drive us? Do we not see in every profession how easily we may fall into certain ruts which, although apparently making our work easy, are in reality impediments to scientific progress? Does not the friction of our own ideas with so many different opinions and practices lead us out of these ruts into the path which a free spirit of investigation requires? My opinion is that in consequence we may be enabled to meet the constantly recurring problems which come to each of us with more enlightened conceptions and broader views. Let us then look back on our past to note as warnings the paths of error in which we all have trod while we push on cheerfully and confidently feeling that the present and the future alike are of the utmost importance to us.

REPORTS OF OFFICERS AND COMMITTEES.

The Secretary, on behalf of the Executive Committee, announced that that committee, acting upon the precedent established last year, had considered that the work of the Association would be sufficiently covered by the report of the President, as had proven to be the case, and in consequence it had no report to present.

The Secretary's financial report, and the Treasurer's report were read by the Secretary, and were accepted and placed on file. The reports were as follows.

EDWIN DARLING, TREASURER,

IN ACCOUNT WITH THE

NEW ENGLAND WATER WORKS ASSOCIATION.

DR.

To Balance on hand at beginning of year as per report of 1885,		$281 78
To Amount received from Secretary,		1658 50
Total Receipts,		$1940 28

CR.

By amount paid Bacon, Stenographer,	$ 94 50	
By amount paid Innis, Stenographer,	25 00	
Quincy House, Boston, expense of meetings Jan. 30th, Feb. 27th, March 27th and May 8th,	24 70	
Paid C. H. Stacy, Postmaster, W. Newton, postage,	131 66	
Paid C. H. Stacy, postage,	4 33	
Paid C. H. Stacy, postage and telegrams,	25 55	
Paid C. H. Stacy, postage and telegrams,	14 63	
Amounts carried forward,	$320 37	$1940 28

Amounts brought forward,		$320 37	$1040 28
Paid expenses September Meeting, 1885.			
Paid A. Bailey, dinner and barges,	$122 00		
Paid A. R. Mitchell, sundries,	9 75		
		131 75	
Paid J. S. Sampson, 150 copies Model Report,		15 00	
Paid Rockwell & Churchill, printing,		7 00	
Paid H. M. Darling, shears,		1 25	
Paid Hooper, Lewis & Co., stationery, etc.,		7 35	
Paid Collins & Fairbanks, badges,		16 25	
Paid Rand, Avery & Co., printing,		22 50	
Paid Fanning Printing Co., printing,		8 00	
Paid Forbes Lithograph Manufacturing Co.,		205 50	
Paid J. G. Roberts & Co., binding 500 Reports,		25 00	
Paid A. Mudge & Son, printing,		25 50	
Paid Boston Copy and Engraving Co.,		4 25	
		$789 72	
Paid for clerical work on Report			
E. A. Wood,	$15 00		
J. C. Whitney,	15 00		
J. A. Baylies,	15 00		
S. C. Conlan,	16.70		
M. E. Conlan,	14 67		
		76 37	
Paid Albert S. Glover for travel and sundry expenses on account Association,		50 00	
Paid A. H. Andrews, blackboard and fixtures,		6 80	
Total Payment,			922 89
Balance on hand,			$1017 39

LIABILITIES.

Bill unpaid for printing report which the committee hope to get reduced,	727 00
Excess of Assets over Liabilities,	$290 30

EDWIN DARLING, Treasurer.

Approved:

R. C. P. COGGESHALL, President.

ALBERT S. GLOVER, SECRETARY,

IN ACCOUNT WITH THE

NEW ENGLAND WATER WORKS ASSOCIATION.

DR.

To amount received from Entertainment Committee of 1885, towards report of April Meeting of 1885,	$16 50
To assessment received on account September meeting at South Framingham, 1885,	95 00
To amount of initiation fees received,	245 00
To amount of annual dues received,	392 00
To amount received from advertisements,	910 00
Total Receipts,	$1658 50

CR.

By amount transmitted to Edwin Darling, Treasurer,	$1658 50

Respectfully Submitted,

ALBERT S. GLOVER, Secretary.

W. Newton, Mass., June 16, 1886.

Approved:

R. C. P. COGGESHALL, President.

The Secretary said for the information of the convention that no member of the finance committee was present, and that by vote of the executive committee the reports of the Secretary and Treasurer had been approved by the President, and there would be no report from the finance committee.

THE REVISION OF THE CONSTITUTION.

Mr. Darling for the special committee upon this subject appointed at the Springfield convention, reported that the matter assigned his committee could only be acted upon constitutionally by the executive committee. The special committee had therefore transferred its responsibilities to the executive committee, which, he understood, was now ready to report,

The report of the executive committee which had been submitted to the members in print was then considered, one or two verbal amendments were made and then the preamble, constitution and by-laws as revised were adopted, and may be found on pages of this issue of the Register.

SALARY OF THE SECRETARY.

Mr. Hyde suggested that the Secretary of the Association should have a fixed salary and he asked for an expression of opinion from the members. The President said he thought Mr. Hyde's idea was a good one, and he would like to hear from the convention in regard to it.

On motion of Mr. Noyes the matter was referred to the executive committee.

INFORMATION RELATIVE TO CAST IRON PIPE.

Mr. Sherman. As chairman of the committee appointed at the Springfield meeting to obtain "Information relative to cast iron pipe," I will state that all three of the members have been quite busy during the past year, and the subjects which we propose to treat are in such shape that it requires considerable data to perfect them, and some money. While the committee has no formal report to make at this time, I will say that we have been in correspondence with many gentlemen, both in and out of the Association, for the purpose of gathering facts pertaining to the topics which it is proposed to treat in our report, and we come to you to-day to ask your indulgence, and suggest that the committee be allowed an extension of time of one year.

At the meeting of the Association in Springfield there was a report "On the proper thickness of water pipes," which appears in the last printed report of the Association. And, at this time, speaking of the funds that we may need in connection with this work, we would ask the consent of the Association to obtain funds outside of the money held by our treasurer. We deem these experiments that are to be made as very important to every individual water works here represented. If it can be determined that a reduction of not over five per cent. can be safely made in the weight of water pipe, it will make a great difference to each water works, and they can afford to contribute to the expense of making the experiments.

The topics which have occurred to the committee, after considerable discussion, we propose to take up in this form.

First: Cast iron; its form and strength.

Second: Cast iron pipes; their methods of manufacture and size.

Third: Their theoretical strength, of various diameters and thicknesses.

Fourth: Their actual strength as found by tests. That is, their commercial strength as we find them on the market.

Fifth: Comparison of theoretical and actual strength.

Sixth: Reasons for the difference if any exists.

Seventh: How near the theoretical strength can we be safe in working, as a matter of practice?

Eighth: How many times the static pressure are pipes subjected to in actual use? That we consider a very important subject. In studying the formulae of the different authorities, we find that the great difference in thickness of pipes is owing to the factor added for this water-hammer, which is a very indefinite quantity, and which can only be arrived at by quite a long series of experiments, by gauges which are set on different systems on pipes subject to local circumstances.

Ninth: What factor of safety shall be used in determining the thickness of pipes to be used under various conditions?

Tenth: How many classes should there be under the various conditions throughout the country? This also we consider a very important topic, for the reason that there are so many different classes at the present time. It would be better for the pipe makers and be cheaper for the authorities who use the pipes, if we, as superintendents of water works should decide that there should be only two, three or not more than four, perhaps not more than three, different weights of a certain size, of a certain diameter, and the

socket-end constant. How much cheaper it would be for the manufacturers to carry patterns in stock to fill their contracts; and it would be a benefit to us as buyers as well as to them. It is the opinion of the committee that the superintendents of the country should work in unison with the manufacturers of pipe rather than against them. Some superintendent comes in and he demands something, which seemingly is a small matter, and he expects the pipe to be given to him at the same price, yet that very little off from the regular the manufacturer of the pipe cannot make without enormous expense, because he is obliged to make new patterns, and the buyers must eventually pay for it.

Eleventh: Table of weights of various sizes for each class, as deduced from the foregoing.

It was decided at a meeting of the committee to suggest these eleven topics at this time, and draw the attention of the members of the Association to them for discussion, so that if possible we could get their ideas as to the best methods of getting the data called for. There is no doubt but what it is a large question. If we reduce the weight of a 40-pound pipe five per cent., it is only two pounds, which at $32 or $33 a ton is only a cent and a half a pound; but when a man is laying 4000 tons of pipe, it amounts to something. And it may be found that it can be reduced more than five per cent. We would like to hear a discussion on these topics. The members may not look at some of them with the same degree of earnestness that we do, but we think that the three topics which I have called particular attention to are the ones which must determine what the practice shall be.

As I said in the beginning, we come before you to-day simply to give this prospectus of what we propose to do, and to ask the indulgence of the Association for another year, and also for authority to ask, over our signatures the individual water works for their co-operation. I would here say that we have already received a subscription of $40. I understand also that the city of Newton proposes to spend $150 in testing pipe, and I have no doubt they will be glad to furnish us with their results.

Mr. Hall. It seems to me that the committee has outlined a work which will be of incalculable benefit not only to the members of this Association, but to the entire country, and I hope they will be given full authority to call for funds, in any such manner as they may deem advisable; or in other words, that they be given full power to act. I think if we can have in two years a report of the result of such experiments as have been suggested to us here to-day, we certainly ought to encourage the committee in every way possible.

The President. The idea I received from Mr. Sherman's remarks was that the committee would in some way address the water boards, state the case and ask them, if they were disposed to contribute to the cost of the experiments. I do not know of any way in which a small sum of money could be invested to better advantage, and I feel sure every progressive water works will be ready to contribute something.

The report of the committee was accepted, another year granted them, and authority given them to solicit subscriptions in the manner suggested.

Mr. Sherman. I would like to make a further suggestion, and it is this, that a great deal of the data which we purpose to collect is to be obtained

by correspondence. Now, those of us who have been on committees know that a great many members of the Association are very dilatory in respond ing to letters or circulars that are sent to them. Now we must have something beside money. We must have the earnest co-operation of every member of this Association. No three men whom you can elect to take up this subject, can carry it through alone. There are no three men in this country who can do it unaided. We must have the earnest co-operation and the benefit of the information which each one of you possesses. That is what we want, and that is what we must have, in addition to money, if we are to make this investigation a valuable one. (Applause.)

Mr. Howland. I most heartily second the suggestions of my colleague the chairman of this committee. We have summarized our plan under these eleven heads, but each one of these heads is capable of considerable sub-division; and, perhaps, to set the members thinking a little, it may be well for me to elaborate one or two of these topics somewhat, and give an idea of what we propose to do in detail, if the Association will bear with me.

The first question that naturally comes up in relation to cast iron pipes is their theoretical and actual strength. That is, what per cent. of imperfection is there in the manufacture of pipes? To get at that, we must make some tests on actual pipes from different foundries, made from different mixtures and under different conditions. The chairman of the committee, Mr. Sherman, has stated that the city of Newton, through its Water Board, has contributed $150 for testing pipes. Our colleague on the committee, Mr. Noyes, as having the direct charge of that for the city of Newton, has already sent 12 lengths of pipe down to the Watertown Arsenal, and we were in hopes they would have been burst by the testing machine there, so that we could at this time have given you the statistics in connection with the pipe, their dimensions, quality of the metal, etc., and their theoretical and actual strength. These twelve pieces of pipe are from two manufacturers. They may give us some idea about what we want to know, but instead of twelve pieces, we would like twelve hundred, and even then we might not be able to give you a conclusion that would be satisfactory in all respects. But the more pieces of pipe we can break, and the greater the number of manufacturers represented, the better it will suit us. Therefore we shall ask the water boards by and by to contribute not only money but pipe,—they can have the scrap back after we are through with the pipe (laughter),—and we think we will be able to get in this way some valuable information for you. I presume a good many water boards would look a little askance at $150 in money, but they had just as soon send along a half a dozen pieces of pipe as not.

In considering the question of water-hammer, and to how many times the static pressure pipes are subjected in actual use, we shall need especially the active and earnest co-operation of every member of this Association. We want to be able to get reports from each superintendent who has charge of a system of works, whether they are purely gravity, whether they are a combination of pumping and gravity, whether they are direct pumping, standpipe, or whatever the system may be, and a plan showing the general system of distribution, sizes of pipes and so on. And then we shall propose, if the parties have not already got recording gauges, to send recording

guages to them, and ask them to connect with their works at some proper points and keep records for a week or ten days, and return them to us that we may compare them, and from the study of them be able to determine, as I think we ought to be able to, the per cent. of water-hammer in relation to the static pressure to which the particular works are subjected. And afterwards we can classify them so that if possible we may obtain the per cent. to allow for the factor of water hammer in the strength of pipes for each particular class of works. When we ask you by and by to help us, we trust you will take hold with a will.

CLASSIFICATION OF WATER RATES.

Mr. Howland, for the committee on Uniform Methods of Classification of Water Rates, appointed at the Springfield convention, made the following report.

Our President last year was very successful in selecting three busy persons to serve upon this committee, Mr. Hathaway, Mr. Glover and myself, and we have hardly had time to more than start on this. We began with the idea that it was a matter of great importance, and one which, if it were considered thoroughly, would entail a large amount of work. From this we did not shrink, however, and as a preliminary step we sent circulars to every Water Works in the United States and Canada, asking not only for their classifications, but for any suggestions in relation to the matter. Our idea was that we would obtain all the reports possible, tabulate them, and then it would be possible to make a study of the subject. We sent out about eleven hundred circulars, and we sent subsequently about three hundred reminders. As a result we have received about seven hundred reports, about one-half of which have been classified and tabulated on large sheets. When this work is completed, we propose to study it to see in the first place what should be the proper basis of assessing the first rate, you might call it, or the faucet rate, which is the common term, whether it should be upon the valuation of the property, whether it should be upon the number of occupants of the property, whether it should be upon the frontage of it, or whether it should be upon the number of rooms.

Very few suggestions have accompanied the replies which we have received. They merely state the classification and say nothing further. From the examination we have made we have found, and we desire to throw it out now as a suggestion, that the large majority of the works in this country use as the basis for the first or faucet rate the number of rooms in the building, and an additional small amount for each additional faucet. And if the committee should find that that was the best basis, it would certainly require the fewest works to make a change. In relation to the other methods of classification, we are endeavoring by our circulars and letters to ascertain the amount of water consumed in the other fixtures, in relation to the first fixture, thereby hoping to fix a percentage to be charged for the second and any number of additional fixtures. We are not attempting to suggest that you shall make a charge of five dollars for every water closet in the country but if your situation is such that you can supply a dwelling of six rooms at, say, $6 a year, your second faucet can be furnished for a certain per cent. of that, the per cent. being based upon what is shown by experience, so that

all rates shall be proportionate to the use of water. As you will easily see, it is going to be quite a job to arrive at fair results. We have carefully read over between six hundred and seven hundred returns, and have probably spent what would be equal to thirty-five or forty days of solid work, and shall probably have to double it before we are ready to make a complete report. We expect to send out some additional circulars to some of our friends, and we hope on this matter, as well as on the question of cast iron pipe, we shall get prompt replies and replies which are not merely printed forms, but which contain a few suggestions which can be put in to leaven the dough which we are kneading so patiently. I would ask for the committee that we have further time.

The report of the committee was accepted on motion of Mr. Hall, the request for further time was granted.

The convention then voted to take a recess until half past seven.

EVENING SESSION.

The convention was called to order at eight p. m. by President Coggeshall.

EXCHANGE OF SKETCHES.

Mr. Sherman, for the committee on Exchange of Sketches, presented the following report:

To the Executive Committee of the New England Water Works Association.

Gentlemen: At a meeting of the Executive Committee held at the Quincy House, Boston, March 27, 1886, it was voted,

"That a committee consisting of Messrs. Sherman of Providence, and Richards of New London, be and hereby are appointed to further the exchange between the members of sketches, and also to consider the advisability of substituting for the plan in the matter already adopted that of having each member furnish only one sketch to be reproduced lithographed and published with the transactions of our annual meeting."

This scheme of interchange of ideas, facts, etc., relating to Water Works by means of sketches of uniform size, was presented, as you are aware, at the Lowell meeting in June, 1884.

At the first subsequent annual meeting held at Springfield last year, ten members brought as many sketches for distribution.

Considerable thought has been given to this scheme to discover if possible sufficient reason why it does not receive more support.

The following excuses have been suggested. First, that the members have no facilities for reproducing in quantity the sketches required. Second, that members are not acquainted with the processes of reproduction and have no time to give to it. Third, that "sheer modesty" holds back many from falling into line, waiting for the time when they shall find a subject for illustration that may be considered colossal.

To test the interest members have in the project it was decided by the committee to request from each Water Works Superintendent "a rough pencil sketch of the general plan of his works" not to any scale, and to contain general statistics.

This request was sent to the sixty-eight Water Works represented according to the official list and twenty-three responded, being one-third.

The information requested was of simple character, such as is given by each Superintendent in every day conversation, probably a hundred times or more every year. He knows it as he knows his own name.

To commit this to paper in a rough way is the work of only an hour at most, requires no apparatus or knowledge of reproduction, and yet the result of the test is far from flattering.

In this case "modesty" had no sway as the committee requested a specific thing which every member possessed.

It was not intended by the committee that the request for the rough general plan should in any way interfere with the original plan for each member to furnish this meeting a suitable number of copies of any subject chosen at pleasure, and it is earnestly hoped that there may be a large increase over the result of last year. As stated in the constitution, The objects of this Association shall be the acquirement and dissemination of knowledge both theoretical and practical relating to the construction, operation and maintenance of Water Works, by social intercourse and friendly interchange of information between its members.

"No fact is understood better than that we do best that work in which we feel the greatest interest."

Shall the verdict then be that this scheme of interchange of ideas by graphical methods fails to accomplish any of the objects for which we convene together?

At some future time another and perhaps a better plan may present itself; but for the present and for want of a better, let us not call this one a failure; on the contrary let each one do his best to make it a success.

It is presumed that we all read the annual reports of our brother superintendents. How much more intelligently they would be read and studied with a comprehensive general plan to refer to.

There are many Water Works represented here in convention asssembled which most of us perhaps will never visit, yet with the general plans before us interest in them is secured.

It may be that in some one plan we may find an adaptation of the very feature we have labored many hours to introduce into our own works without success.

Should this scheme ultimately receive the unanimous endorsement and support from the members it would be well after careful study of these general plans for the Executive Committee or the proposed Board of Editors to suggest from year to year what the subject should be for each member to furnish. In this way in a few years, we should have a complete set of plans of each works here represented which would be of inestimable value and interest to us as Water Works Superintendents.

Those members who have not yet responded to the call of the committee for general plans are urgently requested to do so before the close of this annual meeting. Blank sheets of the required size may be had of the Secretary.

The committee has made some inquiry as to the expense of reproduction

but the amount of "copy" is so uncertain that it was thought best not to attempt any estimate in this report.

Respectfully submitted,

WM. B. SHERMAN,
W. H. RICHARDS, } Comm.

New Bedford, Mass., June 16, 1886.

Mr. Howland. I should like to ask Mr. Sherman in reference to the last remark as to the cost of reproduction, whether that referred to the cost of reproducing the sketches in the annual report, or reproducing them by the blue-print process.

Mr. Sherman. The committee have canvassed the subject of reproducing, in a general way, and it was purposed that the sketches should be reproduced and sent out in the uniform size of ten by fifteen, which was adopted a year ago, and that they should not go into the annual reports.

Mr. Howland. To be sent with the annual reports, but not as a part of them in the sense of being bound up with them.

Mr. Sherman. The committee have looked into this not critically, but, as I say, in a general way, and if we could get the plans,—we could not promise anything of a high degree of execution, it is true,—we think by the use of the cyclostyle we could get something which would be readable and answer all purposes for reference; and we would be willing to waive the point of nicety of execution.

The report of the committee was accepted and placed on file.

Mr. Sherman. I asked Mr. Richards to bring the portfolio, which he has had made for his sketches, and I wish to call your attention to it. (Book exhibited to the convention.) Of course, as yet he has only a few sketches, but I want to impress upon all of you the possibilities in this direction, which perhaps you do not all see with the same eyes that I do, and mine may be a little bit strained so that they exaggerate this a little. Before the election to-day we had one hundred and six active members. Now from those one hundred and six active members, if we could have the co-operation of all of them, we could receive one hundred and six blue prints or reproductions by whatever process. The cost of preparing one hundred of these for distribution is probably about $6.50 to each member; and in return he gets ninety-nine, besides his own, to put into a volume of one hundred pages. Where can you buy one hundred pages of such matter as that for $6.50? You cannot buy it for $200. You can buy books, you can buy Humber's Water Supply, which in some parts is adapted to American practice, and in certain parts is not, and you can buy other books, and after buying enough of them, and getting the meat out of each one, you will finally find what you want and get the whole thing, but you cannot obtain any other one volume of such value so cheaply as you can such a volume as this.

This finished the reports of the special committees, and the next business in order was the election of officers. On motion of Mr. Darling the chair appointed a committee of five to present nominations. The committee appointed consisted of Messrs. Darling, Richards, Parker, Rogers and Noyes.

On motion of Mr. Billings a committee of three was appointed to assort

the sketches, and prepare them for distribution. The President appointed Messrs. Billings, Richards and Sherman.

The Secretary read the following paper by George A. Ellis, C. E., Racine, Wis.

DISCHARGE OF WATER MAINS AS DETERMINED BY THE PRESSURE GUAGE.

At the outset, it will be frankly admitted that measurement of the volume of water flowing in a water main, by means of a pressure guage, is approximate, and that where possible, weir, pump or meter measurement is to be preferred.

The reasons for this preference are two fold, first the inaccuracy of most guages within such narrow limits as it is desirable to read them, when short distances are covered and the velocity of flow is slight; second, as the velocity in this case is measuerd by the loss of head or what is the same, the loss of pressure, a slight difference is noticeable in the results obtained by different experimenters and mathematicians in their attempts to find out the velocity in pipes due to a given length and head.

Before making any practical application of this method, it will be well to ascertain how far these objections govern, and to what extent they can be eliminated.

The first is largely a mechanical difficulty. The gauge must be large and delicate enough to read to the nicety required. It must be so adjusted as to be accurate within the same limits. A very common practice is to place a guage beside one used as a standard, and then if they do not at any point vary more than one or two pounds, to pronounce them near enough for all practical purposes; but this is not true, for our use they should be simply accurate; and having such guages, we must read them with the same accuracy, not attempting to read the average of the vibration of the needle, but throttle down the gauge to the point where the thread of water passing the cock is so small that everything like pulsation of the needle will be avoided, and any change of pressure will be shown only by a very slow movement extending over a minute at least.

The care and attention given to these details will affect the accuracy of the results more than any difference in the formulæ of experimenters.

The second case is almost the reverse of the formula required, with a given length and head to find the velocity, and as this question of velocity or total discharge of any length and size of main is of great consequence to us in the laying of new mains as well as the measurement of the flow in existing ones. I copy a discussion of formula in a paper read by me before the American Water Works Association in 1883:—

"In order to properly appreciate the difference in formula, I have prepared two diagrams showing the resistance in 1000 feet of 12 inch pipe while discharging different quantities of water, computed by different formulæ. The first diagram covers a wide range, from a velocity of zero up to 10 feet a second or 3525 gallons a minute, equivalent to 5,076,000 gallons in 24 hours, and shows the resistance in pounds head or pressure.

The second diagram is more practical in its form, not going above 4 feet per second, or about 1400 gallons per minute, the resistance being shown

in feet head or pressure. This scale is so large that a difference of 0.01 foot resistance in 1000 feet of pipe can be plainly read.

Upon the first diagram at a velocity of ten feet per second.

The FIRST or upper curve is reduced from the formula of Poncelet as given in Trautwine.

$$\text{Velocity in ft. per sec.} = 48\sqrt{\frac{D \times H}{L + 54D}}$$

all in feet. This formula stands first in Trautwine, is adopted by Fairbairn in his treatise on mills, and is substantially the same as that of Hawksley.

The SECOND curve is from the formula of Eytelwein.

$$V = 50\sqrt{\frac{D \times H}{L + 50D}}$$

all in feet. This very nearly agrees with the formula of Beardmore. Of the formula as it stands, Mr. Simpson, President of the Society of Civil Engineers, London, states that he has gauged the flow from many pipes from 1 to 10 miles long, and from 12 to 30 inches in diameter, and found them to agree very exactly with the formula. While of the same, less the addition of 50 diameters in the denominator, Col. J. W. Adams, C. E., of Brooklyn, says: "An experience of over twenty years, confirms as sufficiently reliable."

The THIRD curve is Ellis tables, no formula given. The author lays no claim to originality other than that of clothing a dry formula in practical and easily understood figures derived from tables published in connection with the Providence Water Works.

The FOURTH curve is that of M. Henry D'Arcy, from his formula, from experiments made for the French Government in 1857. The curve is drawn according to the published tables of Col. J. W. Adams.

The formula being in metres, is variously written by English Engineers, Neville gives:

$$V = \left\{\frac{r\ s}{.00007726 + \frac{.00000126}{r}}\right\}^{\frac{1}{2}}$$

all being in feet.

As the denominator in this expression will remain constant in each size of pipe whatever the velocity, we may, following the example of Neville, reduce to its proper terms for every diameter, take from under the radical and dividing unity by the root, obtain the following, r. being 1-4 diameter, and s. the head divided by the length.

For all	4	inch	pipes	$v = 101.69\sqrt{r.\ s.}$
"	6	"	"	$v = 105.29$ "
"	8	"	"	$v = 107.23$ "
"	10	"	"	$v = 108.44$ "
"	12	"	"	$v = 109.28$ "
"	14	"	"	$v = 109.89$ "
"	16	"	"	$v = 110.35$ "
"	18	"	"	$v = 110.72$ "
"	20	"	"	$v = 111.00$ "

"	24	"	"	v = 111.46	"
"	30	"	"	v = 111.91	"
"	36	"	"	v = 112.21	"
"	42	"	"	v = 112.44	"
"	48	"	"	v = 112.60	"
"	60	"	"	v = 112.83	"
"	72	"	"	v = 112.98	"
"	84	"	"	v = 113.09	"

This formula is given in such detail because it has the approval of Mr. J. B. Francis, the first living hydraulic engineer of this country; also of Col. Adams, and in England of Humber, and other authorities.

Made at great expense under the auspices of the French Government, it is undoubtedly, for perfect pipe, laid in perfect line and grade, a nearly perfect formula.

The FIFTH curve is that of J. T. Fanning, from his very elaborate formula:

$$V = \left\{ \frac{2\,g\,h}{1 + C\,r + m\,\frac{l}{r}} \right\}^{\frac{1}{2}}$$

or for the frictional head:

$$h^{11} = V^2 \left\{ 4\,m \right\} \frac{l}{2\,g\,d}$$

But as his co-efficient m varies with each size pipe, and also with each change in velocity, it is impossible to use his formula without his table of co-efficients or calculating them, which for fractional velocities would be very tedious, while above a velocity of five feet per second, there appears no practical difference between the results of his and the D'Arcy formula.

It has, however, the merit (if merit it be) of being the only one shown which changes its co-efficient both for size and velocity.

The SIXTH or last curve is that of Neville, from the formula:

$$V = 140\,(r\,s)^{\frac{2}{3}} - 11\,(r\,s)^{\frac{1}{2}}$$

His co-efficients of friction, although constantly varying with the velocity, are however the same as Weisbach's and the formula the same except algebraically transposed. The curve after being tested by the formula is really drawn from Weisbach's tables as given in Trautwine.

This curve though first at a less velocity than 1 1-5 feet per second, is sixth at seven feet, and from this point rapidly drops below the other curves as the velocity increases. Indeed it is the assertion of both Weisbach and Neville, that the co-efficient of friction at low velocities is more and at high velocities less, than that usually given. Trautwine's comment on Weisbach is, "His extraordinary attainments in science entitle his results to great confidence."

Upon these formulæ, the following comments may be made and therefrom these conclusions drawn.

M. D'Arcy, with France and the prestige gained by the earlier French experimenters in view, made few if any mistakes, he experimented on perfection, or as near that as any one is liable to get, and we have his formula applying thereto.

Neville strongly insists that Weisbach's and his own formula more nearly agree with ascertained facts: but, despite their well known ability, it is

patent to any engineer that their curve is peculiar and distinctive in its forms from all the rest, or in other words, it is "flat", and completely fails to agree with the great mass of ascertained facts as shown by many experiments in different parts of the world.

The curve of Mr. Fanning varies so slightly from that of M. D'Arcy, while his formula is so cumbersome in comparison, especially when the latter is reduced to its plainest terms for practical use, as in the description of D'Arcy's curve, that no extended comment is necessary.

The lower three curves at a velocity of four feet per second may therefore all be classified as theoretical rather than practical. I am well aware that the agreement of the Glasgow extension four feet in diameter, with the D'Arcy formula, is often cited as positive proof of its value; but the very mention of the pipe's diameter is enough to assure us of the quality of engineering that went into the work and the almost perfect alignment necessary even with inferior workmen to keep the spigots in the hubs. It proves only the possible, not the probable.

Indeed, M. D'Arcy himself so well recognizes this fact, that he states that the co-efficient of friction will vary according to the condition and roughness of the pipe, from that given to twice the same, or as the co-efficient is under the radical, it would equal, under the worst conditions, a resistance of more than 41 per cent. over that given by the formula.

Mr. Fanning also recognises this difficulty by giving the mean velocity in clean pipes as

$$50 \left\{ \frac{h^2\ d}{l} \right\}^{\frac{1}{2}}$$

which by the way is almost the same as the formulæ of Eytelwein and Beardmore as shown on the diagrams, while for "slightly rough pipes," he gives

$$V = 44.31 \left\{ \frac{h^2\ d}{l} \right\}^{\frac{1}{2}}$$

and for "very rough pipes,"

$$V = 36.63 \left\{ \frac{h^2\ d}{l} \right\}^{\frac{1}{2}}$$

an increase of resistance of more than 36 per cent.

On the diagrams is shown a curve having 20 per cent. greater resistance than Fanning's formula, or practically his formula for "slightly rough pipe," which is an object lesson of the very great difference in flow produced by slight changes of condition.

As further illustrating the difficulty of treating all the various conditions met in practice, by one rule, notice the fact that the engineers in charge of the New Sudbury Conduit, Boston Water Supply, Messrs. A. Fteley and F. P. Stearns, found by actual experiment, that in that conduit, 9 feet wide and 7 feet 8 inches high, it made an increase in the flow of about 1½ per cent. merely to scrape off the white coating which had gathered on the interior walls. That where lined with pure Portland cement mortar, its flowing capacity was increased from 7 to 8 per cent. When the brickwork was covered with Portland cement wash, from 1 to 3 per cent. While in a long rock tunnel, with concrete floor but ragged rock sides at no place less than two feet wider than the brick conduit, the

co-efficient for velocity was found to be reduced 40 per cent., the hydraulic mean depth being the same; while under the same conditions in some iron coated siphon pipes, 4 feet in diameter, laid as a portion of the conduit, it was found that the velocity was 143 as against 127 in the brickwork.

These suggestions and examples are sufficient to show us that we must look for what we can practically get. And doing so we find that the upper two curves are both reduced from actual trial of lines in use; the second or that of Eytelwein, having a larger support from well known engineers than all the others.

The position of Ellis' tables will be found occupying a mean between these extremes, and is justified by the fact that as knowledge on the subject increases, a better practical result may or should be obtained; while with the well known bias of Americans for economy and high pressures, it is as doubtful if as favorable results as those given by the D'Arcy formula will be reached by any but the very largest of our cities, indeed for all sizes less than 24 inches in diameter, the curve is fully as favorable as the average results; for all sizes above 24 inches a degree of skill and accuracy is likely to be called out, that may lead to an approximation of the D'Arcy formula, although from his modification for the slightest change of condition, it is evidently hardly attainable.

Although any of the formulæ given may be used to obtain the velocity with a known head, or what is its equivalent, a known loss of pressure, I will make no apology before this Association for saying that up to this time the most convenient tables in use for that purpose are those relating to the flow of water in cast iron pipe, computed by Mr. Howland and myself. As to their reliability you can judge from the data given and the curves shown. These tables give the frictional head or resistance in ordinary sized water pipes from 4 to 36 inches in diameter, both in feet and pounds for each 1000 feet in length, the velocity in the pipe in feet per second, and the head necessary to produce the velocity, all for a given number of gallons per minute or the total volume in 24 hours.

These computations are made for every 25 gallons per minute, for 4, 6, 8, 10, and 12 inch pipes, for every 50 gallons for 14, 16, 18, 20, and 24 inch, and for every 100 gallons for 30 and 36 inch pipes.

These tables are carried above any economical conditions in smaller pipes, on the ground that the fluctuation in distribution lines is often excessive and much greater than in the mains.

All the tables are carried to nearly quite double the economical limits if we are to accept the mathematics of good hydraulic engineers.

This limit will vary in various sections of the country and in different cities according to the cost of machinery, water pipe and fuel, and the rate of interest paid on the plant. But it is unlikely that a velocity of four feet a second can anywhere be afforded, with the average less than three.

The tables referred to can be used to determine the capacity of any size water main, by dividing the head (either in feet or pounds) by the length, and thus ascertaining the hydraulic inclination per 1,000 feet. A simple inspection of the tables at the nearest corresponding number under the column of Frictional Head, will give the number of gallons flowing per minute and for 24 hours for all the sizes given.

If the velocity in the pipe should be considerable, it would be necessary to reduce the total head to that actually used in friction, by subtracting the head required to produce the velocity and the loss at the mouth of the pipe, or entrance head, which may be taken at one half the velocity head unless the entrance is bell mouthed, when the loss at that point becomes nothing.

A velocity of 6¼ feet per second can be had before the head required for both purposes becomes one foot. So that for all but very careful computations or very slight heads, the hydraulic and frictional grades may be safely assumed as the same.

For greater velocities a correction will be needed in proportion to the degree of accuracy required, but as the velocity head is given in all cases to the nearest 0.01 foot, and as the entrance head is practically one-half as much, the sum of the two and their effect on the frictional grade or head per 1000 feet can be easily found.

If now we know the distance on any line of pipe from the reservoir or pumps to a pressure guage on the line and the static pressure at that point, we can by observing the loss of pressure and computing the loss per 1000 feet ascertain by inspecting the proper table, approximately the volume flowing per minute.

If the distance and loss are both considerable and the gauge accurate and sensitive, the quantity will be found quite closely.

An inspection of the tables will show what distances and volumes are necessary for successful measurement; in other words, they must be enough so that the loss or difference can be read on the gauges.

If it be desirable to use this method to find the consumption in a given district, which could be isolated by stop gates so as to be fed through a 4 inch pipe, in good condition; two guages attached to hydrants or special connections 500 feet apart, and showing a difference of 1 pound, (after correcting for any difference of their elevation), would mean a difference of 2 pounds for 1000 feet, and would indicate a volume of over 75 gallons a minute, if the difference was 2 pounds, then it would mean 120 gallons.

Again, if the section was fed through a 6 inch pipe, a difference of 1 pound would indicate 230 gallons, or 2 pounds about 313 gallons per minute.

If the guages were 1,000 feet apart their difference, (after correcting for elevation) would be read directly from the tables.

We will now make a practical application of these principles to the historic town of Adam, made famous by the complete report of the transactions of its water department for the year 1900.

This town is supplied by a reservoir on the mountains on the north, through 3 miles of 16 inch pipe, with 231 feet head at the end of the main line, no portion of which rises high enough to touch the hydraulic grade line, or a line drawn from the surface of the reservoir to the lower end of the main. The village itself is situated in a gentle basin, the office of the water department being near the centre of the basin and village. The office guage is about 23 feet or 10 pounds lower than the end of the 16 inch main, the static pressure being at end of main 100 pounds, at office 110 pounds.

The first question we are asked is, how many gallons of water can a 16 inch main deliver per minute. Its length is 15,840 feet; dividing the pressure at the point of delivery by the length, we find the descent for each 1,000 feet to be 14,583 feet, or 6,313 pounds. Refering to "Flow of Water" we find these figures come between 4600 and 4650 gallons per minute; but as the velocity head is 0.84 foot, and entrance head half as much more, we wish to be on the safe side and will assume 4600 gallons per minute to be the total capacity.

What head will this volume of water be delivered under?

Answer,—None.

What has become of the 100 pounds pressure?

Answer,—It has all been used up in bringing to the outlet and delivering that volume of water. Well, our firemen want at least 90 pounds pressure at the hydrant, how much can be furnished at that pressure? Answer,—As the static pressure at the hydrants will be about 10 pounds more than at the end of the main, owing to difference of elevation, we may assume that we must maintain a pressure of 80 pounds at the main. This will be a loss of 20 pounds. Dividing 20 by 15,840 we obtain a grade for 1,000 feet of 1,262 pounds. Turning to table, we find that that loss on a 16 inch pipe amounts to a little over 2,000 gallons per minute.

Now our Superintendent wants to know if he cannot sit in his office 3-4 of a mile from the end of the main, and tell by inspecting his pressure guage approximately how much water is being used.

Not without a little preliminary work. We assumed in starting that there was a difference in pressure between the end of main and office guage, of 10 pounds. Now we must ascertain if the consumption on the distribution lines increases this difference. To do this we will place a tested and compared guage at the end of the supply main and by means of leveling between that and the office guage, or by reading each simultaneously when no water is flowing, find out their exact static difference, (leveling is preferable for you can never be sure with the gates open that no water is flowing). We will now observe during the day by simultaneous reading their variations from the exact static difference; it may be that the circulation is so perfect that none will appear; but this is doubtful.

We will now open hydrants in different parts of the village noting the effect on both the office and main pipe guage, till by repeated experiment we determine their respective losses. Assume we have found that for losses on the main line guage up to 30 pounds, the office guage shows one pound more in every five, or 36 pounds loss at the maximum, (it is doubtful if this loss would increase uniformly, but as it would be determined by experiment, it is unnecessary to go into that point). We are now prepared to estimate in the office the volume flowing. The Superintendent says we have only 99 pounds pressure out of 110, it has run down 11 pounds, that means about 9 pounds at the main. Dividing this by 15,840 he gets 0.568 pounds loss for each thousand feet of main. Turning to table he finds this loss to mean a discharge somewhat in excess of 1325 gallons per minute. While looking at the guage an alarm of fire is rung in, and in a few minutes the pressure drops to 89 pounds. How much this pressure may be affected locally will depend on the location of the fire, but unless there is good reason to the contrary, consider the loss as affect-

ing the entire centre of distribution. We have then, observed loss 21 pounds, actual loss 17 pounds. Dividing by 15,840, loss for each 1,000 feet of main, 1.073 pounds, which in table is shown to equal a discharge of about 1875 gallons per minute, or subtracting 1325 it proves that about 550 gallons per minute was thrown upon the fire.

These figures are approximate, but they serve to show some of the facts that the pressure guage may be made to tell regarding the discharge of water from mains.

Mr. Howland. In relation to the tables referred to, and their use as indicated by Mr. Ellis, I would say that I have depended upon them in several estimates, and on three different occasions have tested them by indications of guages attached to different points on the main line through which the water was being forced by a pump, at which we kept careful record at the same time of the revolutions. And I found them to be correct within eight per cent., that being the largest variation, testing them on 10, 12 and 8-inch pipe. I tested them once on a 16-inch pipe, and I found the difference was greater than that, but I also found, on looking it over afterwards, that mistakes were made in my observations and figures. I will also say that the tables referred to by Mr. Ellis were prepared by us for the American Water Works Association at our own expense. We still have a large number on hand, and I will send them to the Secretary to be distributed gratuitously to all the members of the Association who will apply to the Secretary for them.

The President. As no one seems prepared to discuss the paper, and I admit it is a pretty solid thing to start in and discuss without any preparation, we will pass from it and take up the first topic suggested by the executive committee for consideration at the convention, which is,

SHOULD PLUMBERS BE LICENSED?

Mr. Howland. In my experience, which has been almost wholly with private water companies, I have found it advisable, in order to avoid feeling between the local plumbers and the water company, to stand aloof and independent of the plumbers, and not interfere with their business by doing too much service pipe work. My practice has been to favor generous rules and regulations. But I must say that in one particular instance lately my feelings were most grievously offended. In the city of Montgomery I made some very generous rules concerning plumbing. But the plumbers thought that no restriction ought to be placed upon their operations, and we found they were putting in work unfit to connect with. Some of their customers come to us and said, "We have paid our money for the plumbing. and now we want your water; why won't you connect?" I replied, "For the reason that the plumbing is not suitable." In the case of yard hydrants, the plumbers would state a price, and then would simply turn up a small piece of pipe and put a nozzle on the end of it. But though Montgomery is in the south, it freezes there, and the pipes would burst, and considerable expense would result. We have made up our minds that plumbers should be licensed, and we have already taken the necessary steps to secure the result.

Mr. Richards. The principal effect of licensing plumbers, which I have observed in my experience, has been to give the Water Department a re-

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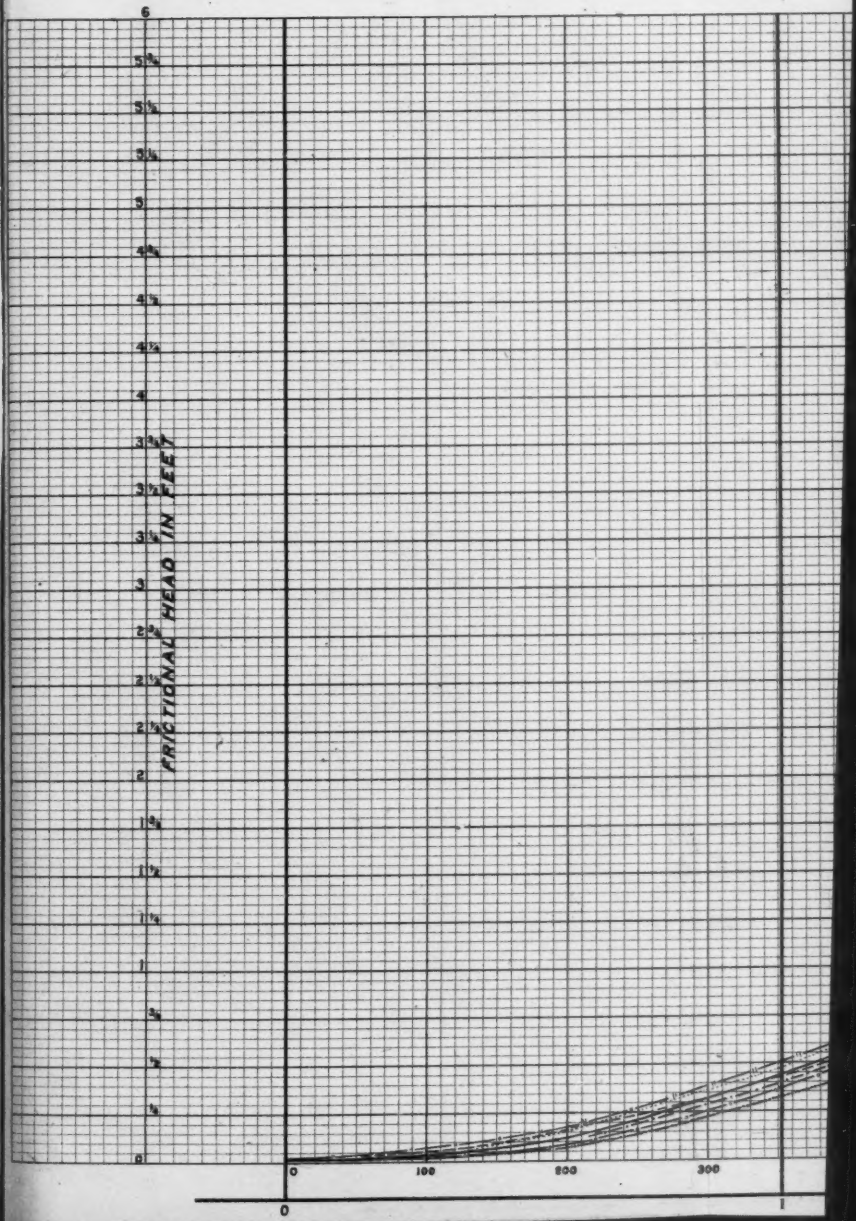

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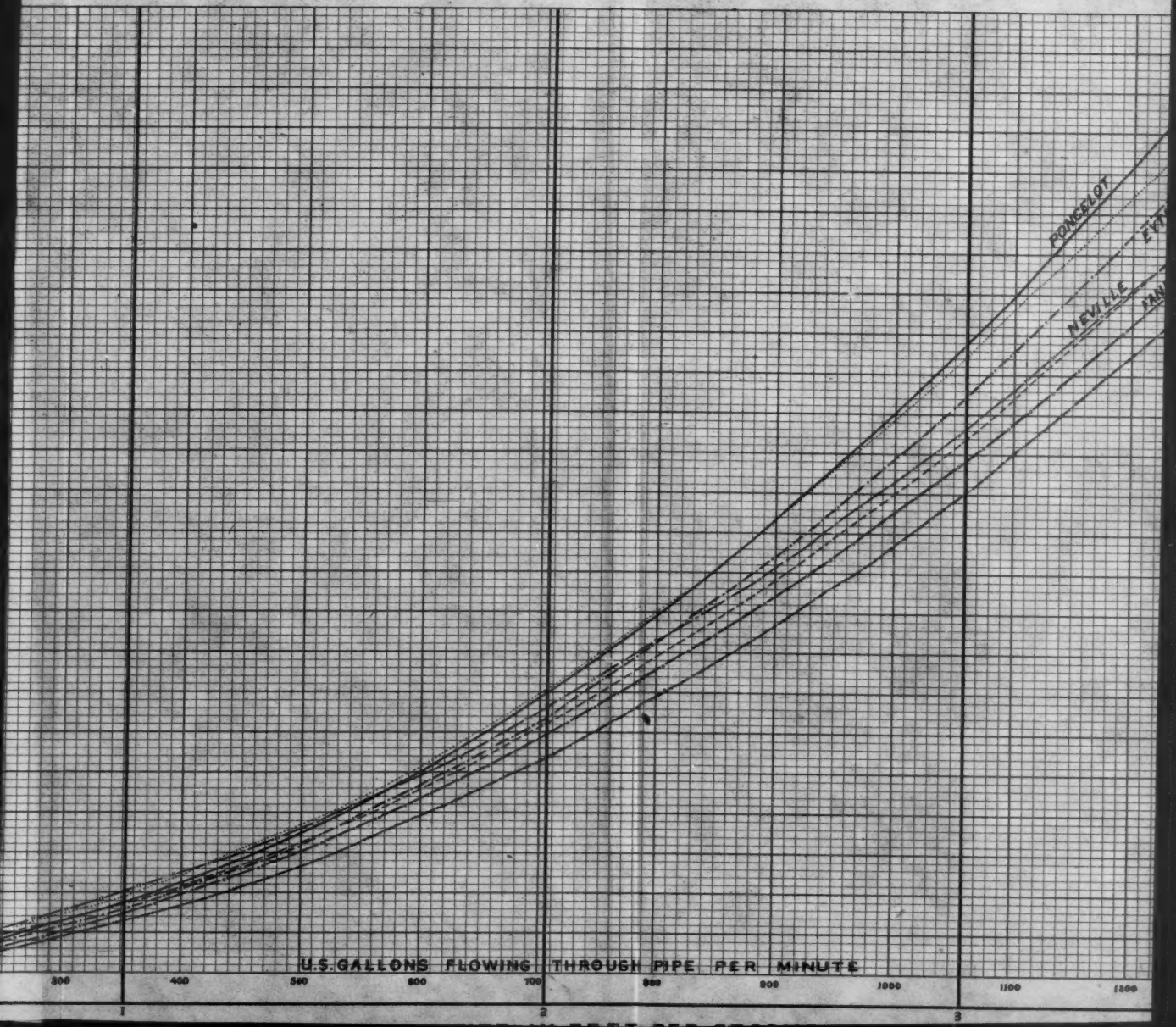

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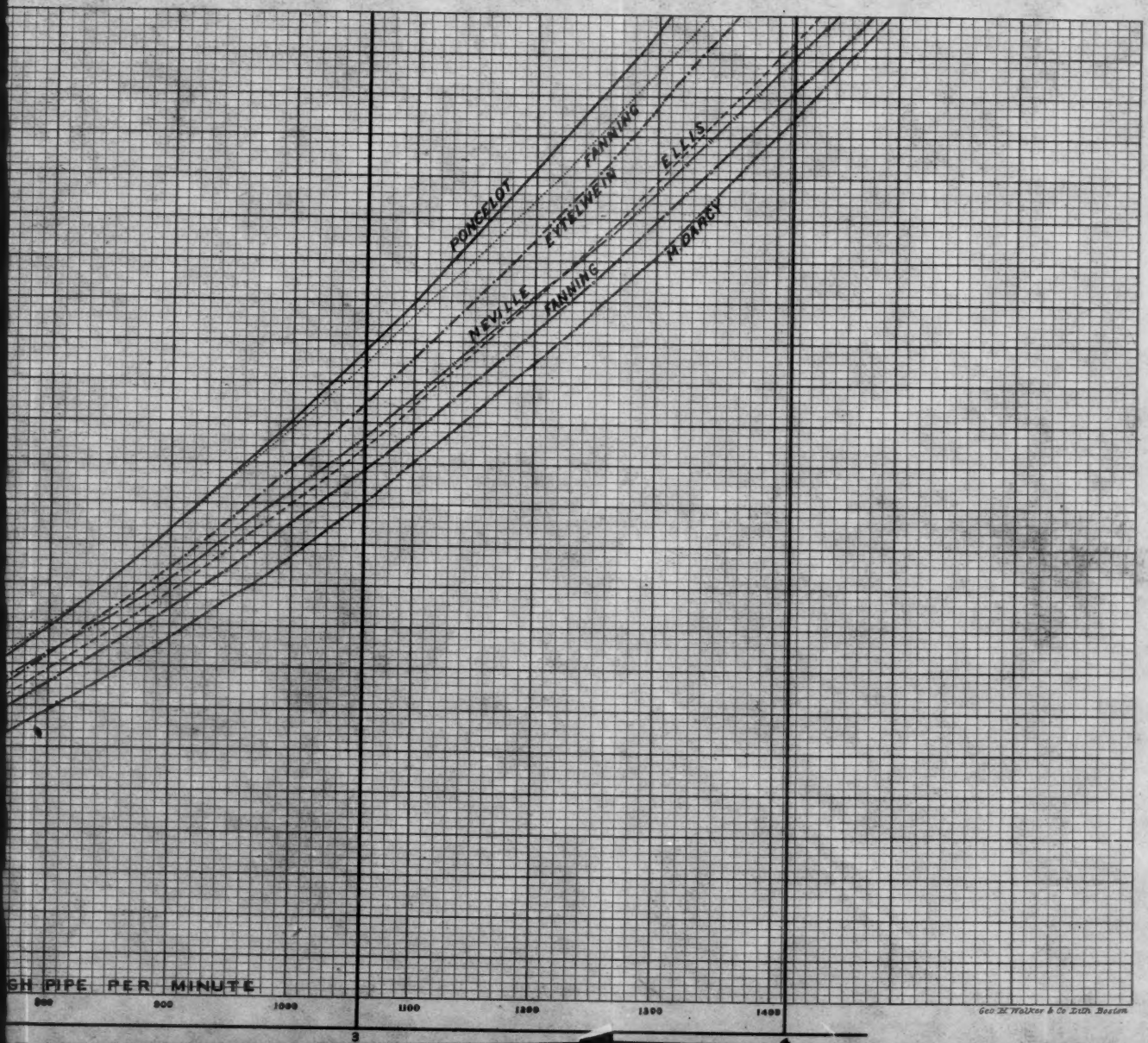

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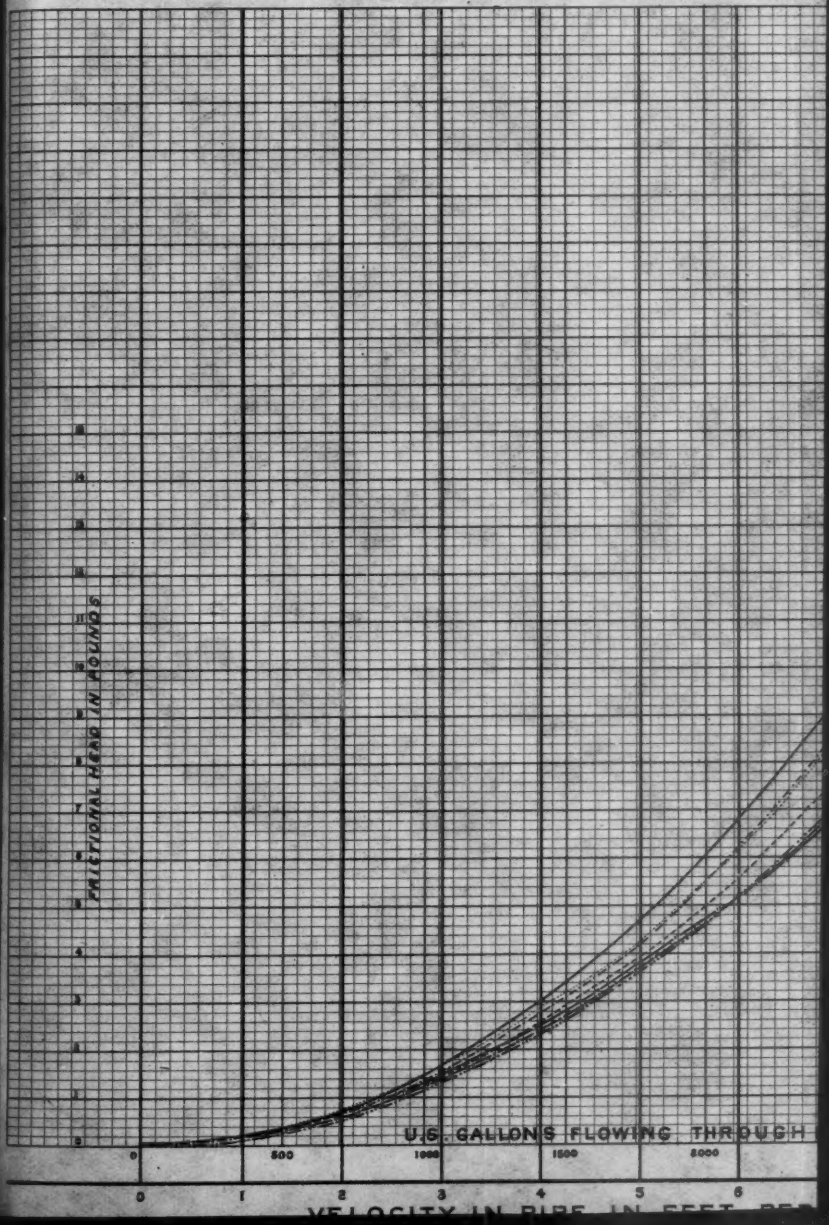

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ACCORDING TO VARIOUS FORMULAE.

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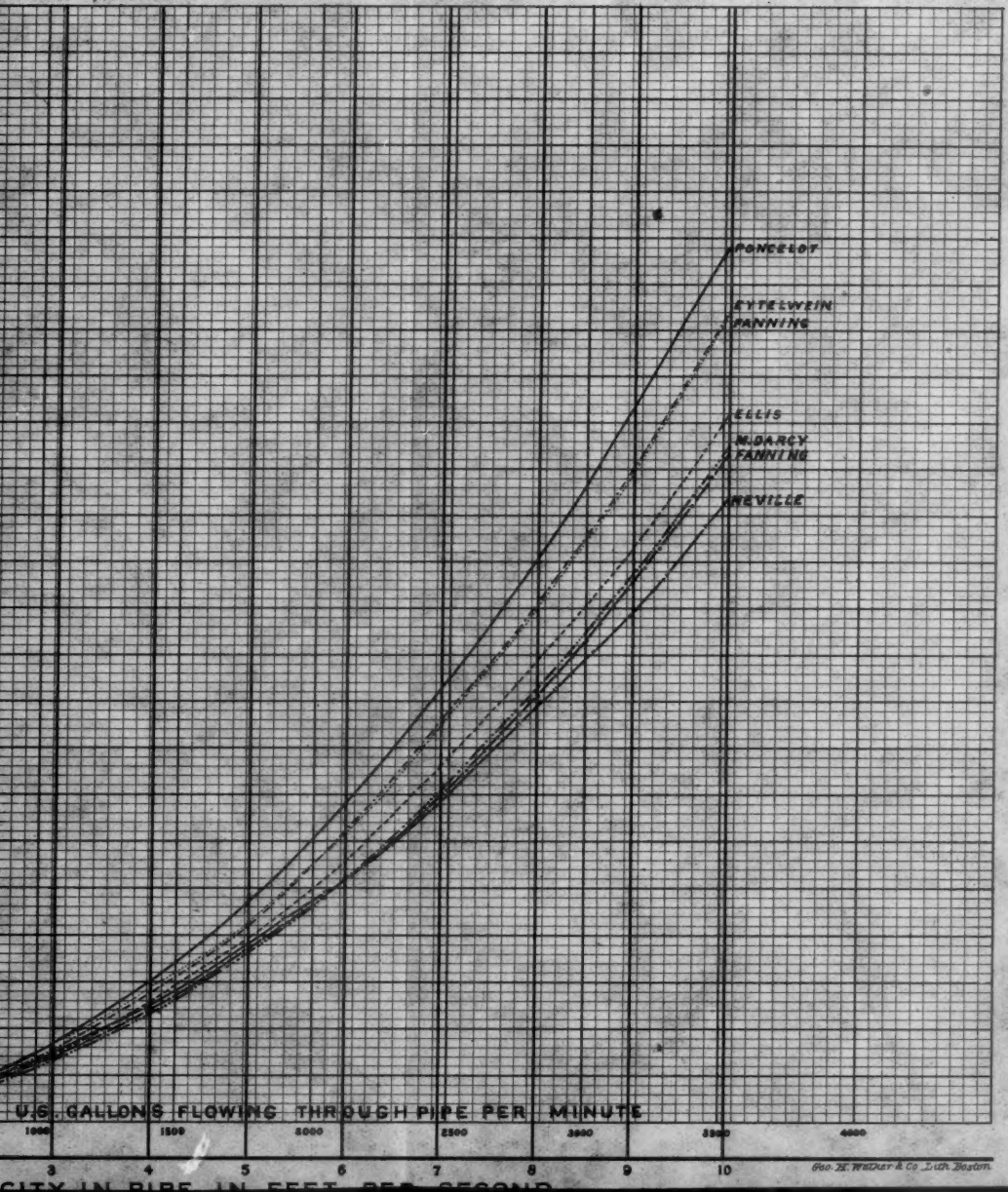

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ELLIS AND HOWLAND, Sept'n

port of the fixtures, for the citizen generally protects himself; that is, if a plumber puts in a pipe that bursts soon after it is put in, he doesn't get another job in the same place. The effect has been that generally the plumbers have done good work. All plumbers are honest men, we know, (laughter), but occasionally they are forgetful, and they don't make returns promptly. When we come to make an inspection we very often find that they have forgotten to report an additional water closet, or a bath tub and that is as far as we have found any use in licensing plumbers. Our experience is not exactly satisfactory, however, and I should like a little light on the subject from some one else.

Mr. Chase. The first effect of licensing a plumber and then preventing him from working if he does not report, is to deprive us of some customers. We do not want to lose the customers; they are just the people we are after. How we can control the plumbers and at the same time get orders, is something we have not figured out.

Mr. Hawes. In answer to the question, "Should plumbers be licensed?" I say no, not more than one out of ten who are now licensed.

Mr. Noyes. My experience, has been more especially with reference to the inspection of works from a sanitary standpoint, rather than in connection with the water supply, and we are now before the Legislature asking for an act authorizing us to license the plumbers. Under the general laws of Massachusetts, the Board of Health has made stringent rules with regard to plumbing. I was appointed inspector by the Board of Health and the question we now wish to determine is who shall and who shall not be licensed. We have at present an ordinance relating to plumbing, in connection with the water ordinance, but I think it is totally ignored by the plumbers, as far as giving any notice is concerned. In framing the ordinance in regard to licenses we shall undoubtedly make it in connection with the water supply, and I am strongly of the opinion it should be done.

Mr. Holden. We have been troubled a great deal in Lowell with bad plumbing, although, I think, we have as good a class of plumbers as can be found. The great trouble with us has been that a large portion of the new houses have been built to sell. The plumbing is executed by contract, and as the consequence everything in the shape of fixtures in such cases is of the cheapest kind. We have also been troubled by pipes being put in where they would freeze, when they might just as well have been fully protected from the frost.

An ordinance has lately been passed providing for the licensing of plumbers, and we propose to have inspectors of plumbing. We intend to give everybody a license who asks for it, but we propose, after the work is done, to have it thoroughly inspected by a competent man, and if the inspector finds the work below a certain standard, it will have to be altered. All our better class of plumbers have been strongly in favor of a license system.

In regard to Newton I have learned that they have an ordinance relative to this matter, for one of our best Lowell plumbers contracted to plumb a large house there: but when informed of the manner in which his work would be inspected, he gave it up, and said he could not do the job unless paid $100 more.

Mr. Noyes. I think brother Holden is a little mistaken about that. We found that plumber to whom he refers to be a very good man. He did not give up the contract, but he went ahead with it, and did a very good job.

The President. If there is nothing more to be said on this topic, we will pass to the next on the list, which is

WHAT IS THE PROPER AND EQUITABLE CHARGE FOR HYDRANT SERVICE?

Mr. Parker. I should charge all I could get. (Laughter.) We get a very small price, however, in our town. We have to fight hard to get $10. I notice in looking over the reports that there is a great diversity in the charges made by the different works in the country. In some places I think it runs up as high as $50. Our experience is that each department of the city government tries to get just as much money out of the appropriation as it can. We have frequently asked to have a larger allowance made, but we have been unable to get it raised.

Mr. Richards. In New London we get nothing for our hydrants, and the consequence is that the Fire Department makes a better showing than the Water Department. It seems to me that there ought to be a pretty large charge, for hydrants, because they certainly reduce the expenses of the Fire Department. The mains have to be very much larger on account of the hydrants, to say nothing of the cost of the hydrants themselves. This is a difficult matter for the average citizen to comprehend.

The Secretary. I think I can make a suggestion for the benefit of Mr. Richards, which may possibly make it easier for him to get something for his hydrants, and that is to have the appropriation for hydrant service separated from the appropriation for the Fire Department. It seems to me a little unjust to charge to the Fire Department the amount that is paid for hydrant service. It looks to me as though that is an expense in the nature of insurance, and ought to be assumed by the city as such. They used to have difficulty about this matter in Boston sometime ago, and I do not know but they have it to some extent now, but not as much as formerly; it was overcome by dividing the appropriation.

In Newton we get an appropriation of $20 for a hydrant. Our gross appropriation for hydrant service is, I think, about $8500, and that is made entirely independent of the appropriation for Fire Department. If it were so included, we probably would not get half as much. Two views in regard to this question seem generally to be taken,—I know it is always argued so in our City Council,—one, that the Water Department should receive only the actual value of the water used; and the other, which of course we entertain, that the hydrants are a source of great protection to the city, and that we should receive something for that. The point I make is that the city should be roundly taxed for that fire protection. I would keep it entirely distinct from the appropriation for Fire Department, and I think the city ought to be willing to pay a good price for it in the way of insurance. I think they ought not to pay less than $50 a year for each hydrant.

Mr. Richards. This had not occurred to me before. However, we do not ask for an appropriation. We do not want any money, but we would like to put the credit on our books. And it seems to me that we ought to

get credit for the amount of water used and for the interest on the extra expenditure in putting in the hydrants. I have not estimated the amount, but I think it would be about $15 a hydrant.

The Secretary. I think it could be figured out in a business way by taking a percentage on the valuation of the property and seeing what the benefit is in insurance.

Mr. Howland. The mere cost of the hydrants is a trifle, but the increased size of the pipes, special castings, gates, pumping machinery, and the reserve machinery which has to be put in for the sole object of furnishing in the minimum of time the maximum of water for fire protection, adds very greatly to what the cost would be if the works had only to provide for domestic consumption. I have had occasion in three instances in the last two years to estimate on the cost of works to supply for domestic consumption alone, and then to supply for fire protection, and the average estimate has been about three times as great in the latter case as in the former. That is to say, we have lying idle in the ground, in our pumping plant, and in the works generally, three times the cost of works sufficient to supply merely the domestic consumption, so as to be ready at an instants notice to supply the water for fire purposes. Of course this varies according to the nature of the works in different places; but each place should, in my opinion, pay for hydrant rental the prevailing rate of interest, four, five or six per cent., as the case may be, on the increased cost, as insurance.

Mr. Schleiter. About ten per cent. of the real estate in our city is using water. We receive $10 per hydrant, which is provided for by a tax levied for the maintenance of the Fire Department, out of whose appropriation the money for the hydrants comes, of course the citizens who are not supplied with city water are taxed for that equally with those who are water consumers; and if there were no hydrant rent paid, they would get the benefit of a smaller appropriation for the Fire Department, at the expense of the water consumers.

Mr. Hall. It seems to me that there is a value to the water furnished greater than the value of the certain number of gallons *per capita* consumed by the water takers. This value is in the decreased rates of insurance which are always obtained in communities that are protected by a water supply. In fact, I know of many places where large real estate owners are not carrying any insurance upon their buildings, relying largely upon the protection afforded by the water works, and at the same time they are not large consumers of water. People who do not contribute to the support of the water works receive the advantage of hydrant protection equally with those who are consumers for domestic or manufacturing purposes. I think that the expense of hydrant service should be met by general taxation rather than by being charged to the appropriation for the Fire Department, or for any special department, for the reason that the general public are benefited, and also because I have always maintained that the expenses of each department should be kept as distinct as though controlled by different authorities.

Mr. Kent. Our works at Woonsocket were built and owned for seven months by a private company. The town entered into an agreement with the company to give $32.50 for each of the first 250 hydrants, and $30 each for the hydrants that were set after that. Since the town bought the works,

I have continued to charge the same rate on the books, but I have not been able yet to collect it. (Laughter.)

Mr. Darling. In a town or city where the works are owned by private corporations, they naturally endeavor to obtain as much as they can for the hydrants. Indeed, that is the main point, for it means a dividend. I think $20 too low, and that about $30 would be a fair price. A regular appropriation should be made for hydrants. This is done in Pawtucket, although the price there is only $20 a hydrant. And we sell to the adjoining town at the same price, the town of Cumberland paying us about $1600 a year. For the town of East Providence we fixed a lump sum of $600 for a given length of time, they having the right to put in as many hydrants as they please. They are paying a little more than $20, because they haven't all of them in yet. The corporation of Central Falls pays $1000 which is little above $20. Now, I claim that the hydrants should be paid for by taxation, whether or not the city owns the works. If they own the works the revenue thus derived should be returned into the Water Department for the purpose of liquidating the interest; or, in case the works are self sustaining it should then be returned into the sinking fund. If the works are free from debt it should go to lessen the general tax levy.

Mr. Chase. The city contract of the company which I represent started out with 75 hydrants at $70 apiece, with the arrangement for the next ten for $63, the succeeding ten at $56, and all after that at $50, taken in lots of ten each. We found it policy in the first season to make an extension, and furnish 30 hydrants at $30 apiece. Further extensions will probably be made in amounts of ten. We have also furnished some private hydrants, one or more at a time, at the average price at which the city hydrants are furnished, which is now a little over $64 a year. Any consumer who wishes for fire protection and will pay the sum of $64, or whatever it is per year, will be entitled to a 4-inch opening in the main, and he can run the pipe into his premises, and attach the hydrant, and use the water for fire purposes free of charge, and also have the $64 worth of water. As an illustration of the extra cost for maintaining the works for fire purposes, I will say that we are pumping not more than 400 gallons of water per minute for domestic uses, but we are liable at any time to be called upon to furnish from 1200 to 1500 gallons more per minute for fire purposes; and any one can easily figure out the extra capacity of the works required to do that amount of work and see how much it costs for fire protection.

Mr. Darling. Economical town authorities sometimes advance the idea that we are paying large amounts of money each year for fire protection and are receiving no benefit. I look upon the hydrant service in the nature of fire insurance.

Mr. Chace. I will say that the city of Wilmington, makes an appropriation for hydrant service entirely distinct from that of its fire department, and thus friction between the water works and the fire department is avoided.

Mr. Billings. I have an impression that it is hardly practicable to fix upon any rate for hydrant service which can be generally applied. When a city has built its works, it finds itself with a plant, which has cost a certain amount of money. It finds a certain proportion of the citizens is likely to use water. But those who do not use it in their houses receive a benefit from

it, as has already been indicated, not only in the matter of insurance, but in the sprinkling of the streets, in the public drinking fountains, and in the general improvement which always takes place in a city after the introduction of water; and it becomes a broad question of municipal financiering to determine how the water rate should be adjusted, and the hydrant service arranged, so as to put a proper proportion of the burden upon the water takers and upon the general tax payer.

I have found that there is a great difference in the practice in different cities and towns. I am sorry I have not the figures at hand, but it is my impression that in some places there is as much variation as this: in one town the water takers pay such high rates that they pay all the expense of running the works, and a very large proportion of the interest on the cost; while in another town the water rates will be comparatively low, and the general tax levy so high that the general tax payer pays all the interest, and the water taker pays only for the running expenses. And there are all degrees of variation between these extremes. The question is one which, it seems to me, must be studied in its local aspects, and not settled by the application of any general rule.

Mr. Howland. Mr. Darling's estimate that $30 should be paid for hydrant rental is, in my experience, about the average price necessary to pay the interest on the increased cost of the works, over what would be the cost of works sufficient to provide for domestic consumption. Mr. Chase is like myself in having a private company, and when we get hydrant rental we have other things in view. But where the works are owned by the city, it seems to me there should be a fixed charge, varying only with the probable extension and increased size of the works from time to time. The consumer should be taxed for the use of the water proportionally to the amount he uses upon the classification of rates, at what might be considered an equitable price for the water under pressure. If the consumption is not sufficient to pay expenses and interest, taken with hydrant rental, then tax the general public enough to make up the deficit. That will vary every year, and will, in most cases, decrease rapidly. But having two fixed rates, one hydrant rental, based upon interest on the increased cost, and the other domestic rates, based upon the amount of water or the number of fixtures used, then a general tax is to be assessed to make up the deficit, which will gradually decrease. And if it should never decrease, but should always remain the same, I think it would help make the people understand that they are getting benefits from the water works, whether they use the water or not, from a sanitary standpoint, from the increased value of the property in the town, and from the bringing in of new people and new industries. A little gentle tax from time to time serves to make the citizens realize they have a water works and appreciate it; and if it could be done without throwing the money away, the application of a little tax under all circumstances would be advisable for the works and for the citizens themselves.

Mr. Billings. Why not include your third item in the charge for hydrant service, and let that vary from year to year as the occasion requires? It is to all intents and purposes a general tax and comes out of the general tax levy.

Mr. Howland. I believe in keeping all the accounts separate, so that the value of each particular item can be appreciated.

Mr. Darling. I have been asked at various times by parties who were preparing to build water works, why a cheaper class of hydrants, using a smaller connecting pipe could not be used, and money saved in that way. My advice to such people was to build their water works so that a good fire duty could be obtained, and then their works would become popular.

The President then announced the next topic on the programme, which was

OUGHT AN APPLICATION FOR WATER SUPPLY TO BE REFUSED, AND THE APPLICANT BE NEVERTHELESS HOLDEN FOR A WATER TAX?

Mr. Cate. I suppose that this question as it is worded would apply to a city where the construction of water works was such that all parts of the city were not equally accessible. The question has probably arisen with some water boards, when application was made for the extension of the mains, whether or not it was for the general interest of the city, whether they could receive a sufficient income to warrant the granting of the application. Now, I suppose, in each city and town the question whether the application should be granted or refused would be decided as was thought just and right. I have had the curiosity however, to ask whether there was not hidden under this a legal question which might make some city or town decide differently from what it might be inclined to. And in looking up what cases I could find in Massachusetts with reference to the matter, I found that they were very meagre; I think there are not more than three or four. As far as relates to a private company, however, I found there was one case which, although it was not a decision, yet went so far as to say that under all reasonable rules and regulations, the water companies not only ought but could be obliged to furnish water.

Now, it seems to me that, carrying out the principle which is generally applied to transportation companies, that they have been granted certain privileges, and have been given the right to tax the public for performing specific duties,—it having been frequently held that they were obliged to take what was offered them, going so far in one case, I believe, as to say that a railroad company could not limit the carrying of parcels by one express company rather than by another,—it undoubtedly would apply in a case where a city had put in water works, and the income from the water department not being large enough to pay for the running expenses of the department and the interest on the bonds, so that any one citizen was taxed for the support of the works, and I should say that the city in that case, provided the citizen making the application complied with all reasonable rules,—and I think an ordinance which would require that the citizen should guarantee a certain per cent. on the additional cost for a specified time would be considered a reasonable rule,—would be obliged to extend the mains to him, no matter what the cost was nor how much it might increase the expense of running the department. I do not state this with absolute confidence, because it has not been decided, but the tendency, so far as I can see from my examination of the law, is in that direction. But even if the judicial decision of that question was in the opposite direction and we were not obliged to furnish water, yet it seems to me that when a citizen is

paying a tax to support the water department over and above what he would be obliged to pay if he had the benefit of the water, the city ought in justice to extend to him all the privileges of the water department, not only the protection of the hydrant service, but also an opportunity for him to take whatever water he wants for domestic purposes.

Mr. Billings. I can confirm to some extent what Mr. Cate has said by our experience in Taunton, for this argument has been used with success there and our City Council has felt its force. We have now begun the extension of a main some two miles long into a very thinly settled territory. The principal argument used to secure the passage of the necessary order through the Council was just about the argument which Mr. Cate has advanced here; and the people on this new line complied with the reasonable requirements, such as he has suggested, in the shape of a four per cent. guarantee running for five years.

Mr. Darling. We started out with the idea of receiving about eight per cent. on the outlay. But after having got to the position where we were paying all our expenses and interest, and passing into the City Government a portion of the sinking fund, we were convinced that there was a good deal of outside territory that ought to be supplied with water, so upon my recommendation an appropriation of $35,000 was made for the purpose of extensions, which we are now making. Now, whenever a man comes and asks for the water, we run the pipe, and while some do not pay more than two per cent. on the cost, others may pay six, but it will not average over four, yet borrowing the money for about three and a half per cent., I feel as though one hand was washing the other.

Mr. Howland. I presume Mr. Darling and others also find that these extensions to a large extent pay better per mileage than any other part of the works — not in the first year, but after the territory has gradually built up. That has been my experience, that it builds up and develops the new section, and the people who go there, having no other provision for water, become water takers. In the old parts of the town there are wells and cisterns. I have found that if you run your pipes out into a new territory, where there are a few scattering houses, if the place is growing at all, it will grow in that direction. There is an equity in the matter, as Mr. Cate has suggested, but I think also it is the best policy.

The Convention then adjourned to Thursday morning at 9:30.

[Thursday morning at 8:30 the members of the Association visited the workshop of the New Bedford Water Works and inspected the premises. Much favorable comment was expressed at the convenience of the arrangements. A portable tool-house built by Mr. Ashley, foreman of the shop, with as many lockers as a yacht's cabin, attracted much attention, as did also a large derrick used in laying heavy pipes. Some service stop-boxes made in two sections so that the top might be loosened by the frost without disturbing the bottom were also much and favorably noticed. The blue-print room and meter room were visited and the visitors expressed themselves as much pleased with all the arrangements shown.]

THURSDAY'S SESSION.

NEW BEDFORD, June 17, 1886.

The Association was called to order at 10 A. M. by President Coggeshall.

ELECTION OF OFFICERS.

Mr. Darling, for the committe to nominate officers of the Association for the ensuing year, reported the following as the unanimous recommendation of the committee:

Prsident — Henry W. Rogers, Superintendent, Lawrence, Mass.

Vice Presidents — J. C. Broatch, Superintendent, Middletown, Conn.; F. H. Parker, Superintendent, Burlington, Vt.; Benjamin S. Babcock, Superintendent, Nashua, N. H.; George P. Wescott, Superintendent, Portland, Me.; Thomas C. Lovell, Superintendent, Fitchburg, Mass.; Willard Kent, Superintendent, Woonsocket, R. I.

Secretary — Albert S. Glover, Registrar, Newton, Mass.

Treasurer — Edwin Darling, Superintendent, Pawtucket, R. I.

Senior Editor — Robert C. P. Coggeshall, Superintendent, New Bedford, Mass.

Junior Editor — William R. Billings, Superintendent, Taunton, Mass.

Executive Committee — George A. Ellis, Hydraulic Engineer, Racine, Wis.; Walter H. Richards, Superintendent, New London, Conn.; Frank E. Hall, Superintendent, Quincy, Mass.

Finance Committee — George E. Batchelder, Registrar, Worcester, Mass.: Nathaniel I. Jordan, Treasurer, Auburn, Me.; Walter H. Harding, Registrar, Cambridge, Mass.

On motion of Mr. Sherman the report was accepted, and on motion of Mr. Chase the Secretary was instructed to cast the ballot of the Association for the list as presented, which he did, and the President declared the gentlemen named to be elected.

The next matter in order was the reading and discussion of papers, and the President called upon the Secretary to read the following paper by Col. J. T. Fanning, C. E., on "Information Relative to the Best Type of Water Power Pumping Machinery":

TYPES OF HYDRAULIC PUMPING MACHINERY.

BY J. T. FANNING, C. E.

Song and story, from ancient times have abounded with grateful allusions to the fountains from whence came the people's water supplies. Tradition relates that many wells and flowing springs were so revered as to be deemed sacred, and in mythologic times to be deemed homes of guardian deities.

When the Psalmist prepared a song for the Chief Musician of the Temple, to acknowledge the blessings that came to God's chosen people, he placed first among the blessings received, "Thou visiteth the earth and waterest it."

Water is the emblem of gifts most desired, and the most precious of Nature's bounties.

To members of this Association is committed the privilege of distributing this choice blessing among the people.

Notwithstanding the weariness and sense of never ceasing responsibility that often presses heavily, there are cheering features pertaining to our labors when we maintain the blessing of abundant water flowing continuously in cottage and mansion alike.

The "pitcher at the fountain," "the wheel at the cistern," became emblems of sorrow and lost hope only when they were *broken*. These emblems remind us that water was not distributed without severe labor in the olden times when the hand-maidens bore the burdens of the pitchers, going out at morning and evening and returning with brimming vases on their heads.

SCOOP WHEEL.

Probably the earliest type of hydraulic machine that began to lighten the labors of the water bearers, was the Scoop Wheel, and of this and other hydraulic machines of most frequent use, previous to the medieval age, fortunately we may gain a fair conception in the illustrations by Vitruvius.

The Scoop Wheel was suspended on bearings over a stream, and on the outer extremities of its two or more series of spokes were buckets formed like troughs, which served also as paddles to keep the wheel revolving. The buckets dipped into the running water and were filled successively as the wheel revolved with the current.

In a primitive form of the wheel a tight boarding extended across the wheel from spoke to spoke and radially from axle to bucket. When the bucket came to a level a little above the axle, its waters began to spill on to this boarding and run down towards the axle and along the axle to one end of the wheel where a tank or trough received the water.

We might on first sight think this elementary machine a very crude construction.

In reality, in was a splendid invention and revolutionized a system. It substituted the power of a running stream for the power of human muscles in lifting a water supply, and one machine performed the labor of many maidens and slaves with their pitchers and various devices for lifting water by manual power.

This type of wheel handled relatively large quantities of water, but the lift was always a little less than the semi-diameter of the wheel. After later improvements this wheel resembled somewhat in general appearance the breast-wheels used a generation since in New England cotton mills, except that the buckets and direction of power were inverted.

NORIAS.

A second marked advance took place in water elevating machines, when tilting buckets and pots were attached to the perimeter of the wheel in place of the scoop buckets, for the height of the lift and discharge of water was then increased to nearly the full diameter of the wheel.

Later, the fixed buckets were improved in design so as to spill the water out at their ends when they were near the highest point in their revolutions.

This last form of Noria received many modifications and improvements in Egypt, Persia and China, and much more recently in Europe. This type of machine became exceedingly efficient, and is occasionally met now,

even as the bearers of pitchers have to-day their representatives in Spanish and Mexican cities.

Recently the writer saw a machine of this class emptying a dry-dock in Buffalo, N. Y., where it was said to have done good service many years.

Ewbank quotes Buckhardt's description of similar wheels lifting the water supply of Hamath in Syria, where, he says, there are a dozen wheels, from thirty-two to seventy feet in diameter discharging their buckets in a stone aqueduct supported on lofty arches, and Ewbank suggests that these wheels probably remain much the same in form as when the city flourished under Solomon. The Hamath wheels were revolved by water power, but oftener on the plains bordering on the Nile and Euphrates smaller wheels of similar form were turned by manual or animal power.

CHAIN OF POTS.

There was evidence of another inspiration of genius when the pots of the Noria were fastened to the chains and the chains hung upon the wheel as a long, loose, endless belt. Then the entire wheel could be lifted above the water, or the water drawn up from a deep pool or well and discharged near the highest part of the wheel.

This type has been much used in different Asiatic civilizations. If the well was deep, one series of pots lifted the water a portion of the height, and another series to the surface of the ground. An oft quoted example is the remarkable "Joseph's Well," at Cairo, so ancient that the date of its origin cannot be fixed; its depth is 297 feet, and its construction was adapted to two series of chains of pots with a tank at mid-height.

This type might also be used if the field or palace or garden to be watered, was high above the source of water supply, as the reputed hanging gardens of Babylon, for then the two or more series of chains of buckets, one above the other, might lift the water to the desired height. About the beginning of the christian era, the Roman buckets of this type for elevating water were not unlike the metal buckets for lifting grain in our modern wheat elevators. In pictures of examples of the chain bucket type, we sometimes see the wheel that carries the chain, elevated above its foundations and a series of spokes closely placed near one end of the shaft.

Under the wheel shaft stands a vertical shaft with short spokes meshing into the other spokes.

This lower shaft is turned to revolve the bucket wheel shaft above by men or animals walking around it, or by force of a running stream. Here in the meshing spokes of twenty centuries ago we find the germ of the bevel wheels so common in modern power transmiters.

CHAIN DISKS.

A type very naturally succeeding the chain of pots was the endless rope or chain, with disk buckets rising through a square tube, and passing over a wheel, bringing water up to the top of the tube. This type, in good mechanical form and on a small scale has been popular in the cottage and farm house wells of New England during the present generation, and we are familiar with it, when the tube is inclined, as a favorite form of contractors' pump. Its merits have saved the type from the beginning of his-

torical record, for such machines have sufficed in China from time immemorial, to water the fields.

ARCHIMEDIAN SCREW.

All the types above described antedate, by many generations the screw water elevator. This was a favorite pump on Roman ships but of comparatively limited adoption and rarely moved by hydraulic power.

All the types thus far described were valueless water elevators, and we note this peculiarity; that none of them elevated the water above the summit of the moving mechanism.

BELLOWS PUMPS.

None of those ancient but valuable types of hydraulic machines heretofore alluded to, called to their aid the pressure of the atmosphere.

As the use of the bellows was common at the earliest period of history we may readily surmise that a similar machine for sucking and pressing out water was among the earliest forms of pumps fed by atmospheric pressure. The syringe, also of great antiquity is an apparatus containing a piston for forcing water.

The combination of these two types in the hands of an ingenious mechanic was probably the origin of the modern atmospheric pump in the early Asiatic or African civilization.

AIR VESSEL ATTACHMENT.

To Tesibius, a renowned mechanician of Alexandria, of the time of Ptolemy Philadelphius, is attributed the honor of adding to the piston forcing pump the *air-vessel* and realizing the steady continuous flowing jet, and Vitruvius has described his great machine, which had two metalic pump cylinders and reciprocating pistons and was moved by an undershot wheel placed in a flowing stream, and supplied the public fountains with water. This is the type which went through many modifications in the hands of the mechanicians and philosophers of the middle age when the supposition prevailed that suction of water by the pump was due to "Nature's abhorence of a vacuum."

It was twelve centuries later than this when Gallileo suggested, and Torricelli proved, in Italy, by experiment that the so called "suction" of the pump was due to the pressure of the atmosphere; and his theory was denounced as rank heresy.

A great advance in type had been made when the air vessel changed the intermittent into continuous flow and eased the labor and strain upon the machine and a practical pressure pump was the result of the invention. Therein was the parent type in Egypt, two thousand years ago, of what has become the general substitute for the pitcher at the fountain and the wheel at the cistern for supplying households with water.

PLUNGER PUMP.

In 1675 Sir Samuel Moreland invented and introduced a new modification known as the Plunger Pump, with smoothly turned plunger working in a stuffing box at the top of the pump cylinder. This type found extensive use in the Cornish mines and later in many British water supplies, and more recently at Jersey City, Louisville and Providence.

DOUBLE ACTING PUMP.

In 1716 La Hire first described in Memoirs of the French Academy his

double acting pump, with piston, having two sets of admission and two sets of discharge valves. This also was an important advance in type, as a cylinder of given size could send forward nearly double as much water per revolution as the single acting pump, and the flow was much less intermittent.

An improved form of this type is familiar to us in the Fairmount pumps at Philadelphia, also in pumps at Montreal, Cincinnati, etc.

BUCKET PLUNGER PUMP.

These types were soon followed by the combined bucket plunger pump, in the "Simpson," English engines; and illustrations are familiar to us at Lynn, Lowell and Manchester; and this type has by several inventors been modified into a differential plunger form.

A still more recent favorite is the double acting plunger type, of frequent use in American public water works, and produced in horizontal and vertical forms by a number of prominent builders.

REVOLVING PUMPS.

The sixteenth and seventeenth centuries gave us several good variations of the rotary and centrifugal types of pumps, the best principles of which appear in those classes of pumps to-day.

The centrifugal type seems not yet to have reached the best possibilities of its class, and its mechanical elements are believed to be worthy of further investigation and experiment.

MOTORS.

Nearly all these types of pumps have received motions from successive types of water wheels. The oldest motors are supposed to have been current paddle wheels like the scoops above described.

Following, came other types of horizontal wheels, for which the water was controlled by weirs or canals, to some extent.

These forms are familiar as the undershot, breast and overshot wheels, with horizontal shafts. The early part of the present century gave us the Fourneron and Fontaine turbine types of water wheels with vertical shafts, which have been followed by numerous modifications of downward, outward, inward and upward flow turbines. These have been favorite motors for driving pumps, but they have usually involved the use of the mitre or bevel gears to change the motion to horizontal shafts and the best successes have usually required intermediate gears between motor and pump to regulate the speed of reciprocation of the pump.

COMBINATION.

The pump and the motor are usually independent, and a hydraulic pumping machine is a combination of the two mechanims.

Almost any type of pump may be driven by any type of water wheel.

There is a broad field, as indicated in the greatly varied types of pumps and motors herein alluded to, for exercise of the skill and ingenuity of designers of hydraulic pumping engines, if they desire most efficiently to adapt and combine, or to newly invent a mechanism that shall best perform a required special duty.

Glancing over the prominent types of pumps and motors enumerated, we observe that each in succession was eminently well, and probably the best adapted for the purposes and skill of the people who made and used them,

and that improvement in type, accompanied advance in mechanical skill in civilization. The admirable pieces of mechanism that force water throughout the arterial systems of many New England cities would have confounded the Water Superintendents of the Phœnician aqueducts, yet the skill of the builders of the Carthagenian conduit remains still unsurpassed in its class of workmanship.

The feature that is distinguishing the most recently constructed hydraulic pumping machines from those of a decade or more ago is their special adaptation to direct pressure pumping, whether or not intended to pump ordinarily to a reservoir or tank stand-pipe.

The turbine wheel and double acting plunger pump, in the present state of mechanics, is undoubtedly the best combination for direct pumping, in localities where reliable water power is attainable. The combination may be reduced to the utmost simplicity of mechanism while retaining the maximum of efficiency, and can respond with almost instantaneous promptness to a required increase of pressure in the water mains and adapt their motions with great efficiency to variations of draft of water.

These qualities are very valuable in a public water works pumping machine.

In illustration of this type of machine, a sketch is presented showing pumps and turbines recently set in operation in Connecticut.

Two turbines are here placed on the same horizontal shaft, and thus the use of two sets of bevel gears eliminated from the usual pump and turbine combination. The turbines are separated a sufficient distance so that two pairs of pump cylinders may stand between the iron penstocks leading water from the fore-bay to the turbines. On the shaft connecting the two turbines are placed two spur gear pinions; each pinion drives the main mortise gear wheel and cranks, that move one pair of pumps. A coupling in the main shaft between the pinions may be unfastened and then there are two complete and and independent pumping machines. Each pinion on the main shaft has a long feather key that permits it to slide in or out of mesh with the main gear, and it is drawn in or out, and held in either position by a screw.

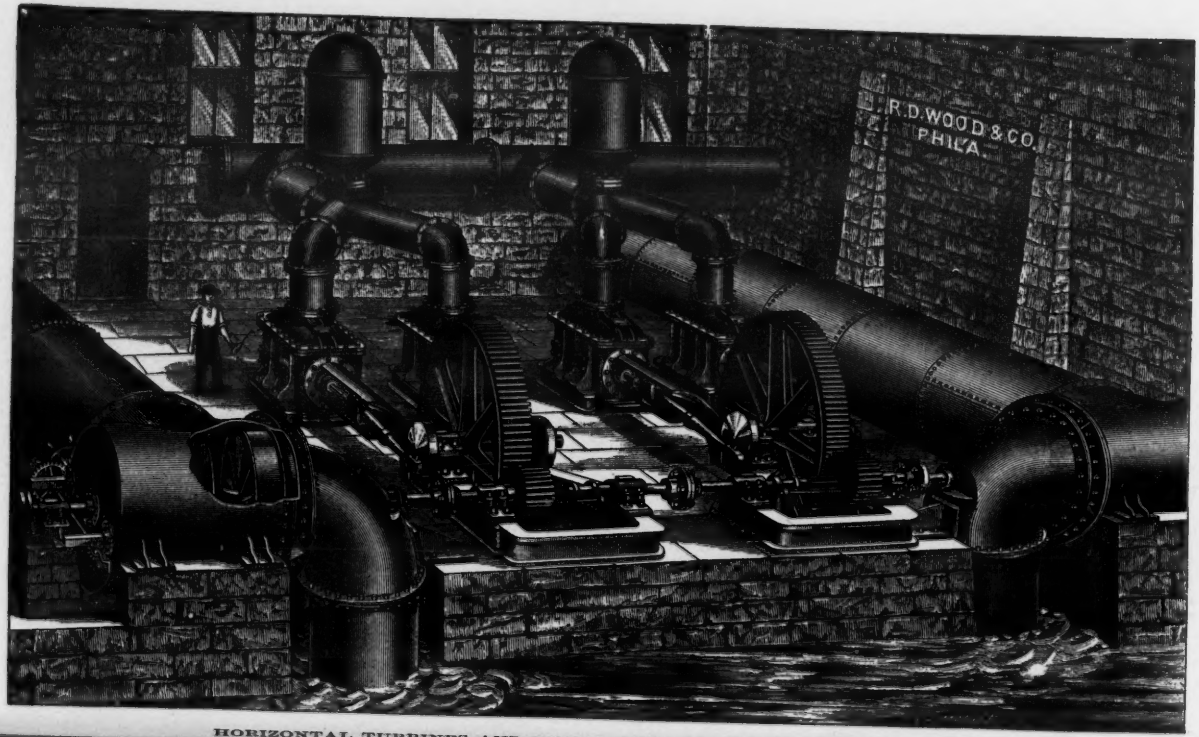
When the central coupling is fast the entire combination of pumps and turbines work in unison as one machine, or by sliding a pinion in or out of mesh, as the case requires, either turbine may drive either or both pairs of pumps, or both turbines may together drive either single pair of pumps.

These separations or combinations may be quickly accomplished.

The combination is more than usually guarded against total disability by an accident to any of its parts.

There is a relief valve of ample capacity attached to the force main within the pump house. The simplicity of mechanism in all its parts adapts it well to direct pressure pumping as occasion shall demand, but the usual daily work of the pumps is to force water for a public supply from the river, at the forebay, to a reservoir, with a lift of two hundred and eighty feet. The reservoir is about two and one-half miles distant from the pumping station and is located on the opposite side of the distribution, so that the pumps force the water directly into the distribution and the reservoir acts as an equalizer of pressure.

The President. This paper illustrates the idea that I tried to bring b -



HORIZONTAL TURBINES AND PUMPS.—WILLIMANTIC WATER WORKS, CONN.

fore you in my address. Such papers, or an abstract of their contents, should be in the hands of the members at least a month before the assembling of the convention, in order that gentlemen may prepare themselves for the discussion. As no one seems disposed to make any remarks upon the subject of Col. Fanning's paper, and as Mr. Fitz Gerald, who is to read the next paper, has not yet appeared, we will occupy the time until his arrival in considering the next topic upon our list of "Topics for Discussion," which is

WHAT IS THE BEST FORM FOR SERVICE BOX AT STREET CURBING?

Mr. Holden. My ideal of a service box is something that can be easily found at any time of the year, and that will remain at the same grade with the sidewalk, so that there may be no necessity for digging in order to get at it. This form of service box (sample exhibited) is something which we adopted about two years ago, and I find it works better than anything that I had formerly tried. Our boxes used to be made out of inch and a quarter lumber, and were supposed to last a great many years. I find the durability of kyanized lumber is about double that of lumber that is not kyanized. I also like a service box, the cover of which can be easily taken up. I know that in a great many cities no one except the employes of the water department is allowed to meddle with the service pipes. We give our plumbers permission, when they have completed a job of work in a house and wish to test it, to turn the water on and shut it off without sending to the water office. The understanding with all the plumbers is that they must leave the service as they find it, and it is very rarely that they do not. All our masons have wrenches so that they can take the water for mixing their mortar and plaster from the service pipe, which, of course, is connected on to the house before the house is finished, and the understanding with them, also, is that they are always to leave it as they find it, and I do not know of a case in which they have not done so.

A somewhat lengthy discussion upon the expediency of allowing any one outside of the Water Department to turn water off and on, followed these remarks of Mr. Holden. Messrs. Hyde and Coggeshall contended that justice could be done to all concerned without allowing the business of opening and shutting sidewalk cocks to go out of the hands of the Water Department, while Mr. Holden held to the opposite opinion. The cost of the New Bedford service box was said to be about $2.10, and that of the Lowell box about $1.60.

Mr. Desmond Fitz Gerald, C. E., of Boston, then read the following paper, entitled

RAIN FALL; THE AMOUNT AVAILABLE FOR WATER SUPPLY.

I know at Conventions of this kind it is desirable not to present too elaborate papers, and I shall therefore endeavor not to detain you long. I intended to have written out carefully what I have to say on the subject upon which I have been announced to speak, but have been unable to find the to do it fully. This subject of rain fall is one of the most important, that can engage our attention, especially when we consider in

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connection with it the amount of water that is available for the uses of man. It has particular interest for those of us who are engaged in the construction and management of works for the supplying of water to cities and towns.

It is only within a comparatively few years that the rain fall has received very much attention in this country, and it is surprising how much misinformation there is in the popular mind on the subject. You can hardly take up a paper without reading something about the influence that the removal of the forests has on the amount of rain that falls from the clouds; and even among scientific bodies there does not seem to be any very definite knowledge in regard to this matter. Not a great while ago I read a statement, made at a meeting of one of the Western societies, that since the construction of the Suez Canal the planting of a few trees along the banks of the canal had had the effect of increasing the rainfall. This was such a direct assertion that I took the pains to write to Mr. De Lesseps, the chief engineer, and received an answer from him, as I expected, to the effect that the time had been altogether too short for them to get any results from the planting of trees, and he would not venture to give any opinion on the subject whatever.

In England, where water is of more value than it is with us, and where they have had more time for the investigation of every phenomenon connected with rain fall, percolation, storage, evaporation, etc., there are more than a thousand observers of rain fall gauges, on an area somewhat larger than that of the New England States. If we look at a map of the United States, on which the mean annual rain fall is plotted, we shall find a considerable range in the hyetal areas. I have had sketched on this map in a rough kind of a way the mean annual rain fall over the whole country and the areas run from less than ten inches in some sections, here where these parts are unclored, to eighty inches, in a small district there on the Pacific Coast. You can see what a variety of results there are.

(Attention was here called to the distribution of rain on different portions of the map.)

Here in the Gulf and in the Gulf Stream we have an immense mass of very warm water. In a trip I recently made to the West Indies, I took the temperature three times a day. I started from New York with a temperature of forty-six degrees, which continued until I struck the Gulf Stream off Hatteras, and then the thermometer jumped up immediately to eighty degrees, and remained at eighty degrees all the rest of the way to Nassau. You thus see what an enormous difference there is in the temperature of the ocean in a very short distance. From this mass of warm water, there must be an enormous evaporation. This is the great source from which we get our mean rain fall. There is a small district along the coast, which receives a slight increase from the Atlantic. When you get out here beyond the Mississippi it is pretty dry, because the rain fall coming from the warm Pacific currents has been condensed against the tops of these mountain ranges and the clouds are almost entirely robbed of their moisture. We thus get a very low rain fall on the plains on the easterly sides of the mountains.

The mean of some thirty years of observation on the rain fall of Boston gives us yearly about forty-eight inches; and this forty-eight inches is so

equally distributed through the several months that we may safely say that on an average we have four inches per month, though not exactly so, as we will presently see. If we examine a profile of the different years, we shall find a great variety in the amounts, running in a general way from thirty to sixty inches. The irregularity in the outline does not suggest any particular law of increase or decrease; in fact, our periods are rather short for this purpose. Within the last few years, however, we have had two very dry years, as most of you probably know who passed through 1880 and 1883; and it is to those two years that I particularly desire to call your attention to-day, as there are several valuable lessons to be learned from their careful study.

In 1880 we had on the Sudbury River water shed 38.1 inches, and in 1883, 32.8 inches of rain. On the Cochituate water shed adjoining we had 35.9 inches in 1880, and 31.2 inches in 1883. These figures agree sufficiently well, but in discussing the available amounts received, I prefer to take the larger water shed, namely, the Sudbury River, which has an area above our lowest dam of about 74 square miles. The Cochituate water shed adjoining covers about 18 square miles.

There have been a great many figures made from the results of the Cochituate rain fall, because we have such a long series, running from 1852, and on the Sudbury for ten years only. I think the results on the Cochituate are hardly as reliable after you go back a few years, on account of the imperfection of the methods of taking the rain observations.

And perhaps this is a good place to speak about the necessity of having a good gauge and seeing that it is properly exposed. All sorts of erroneous conclusions are drawn from imperfect data, and it is very desirable for us all to endeavor to get our data as correctly as possible. Some time ago for the New England Meteorological Society, I devoted some study to the question of gauges, and I found our standard gauge used on the Sudbury and Cochituate, which is 14.85 inches in diameter, a very convenient size when the water is weighed, but there are a great many reasons why it is rather a large gauge for ordinary observers; and I have found as a result of a couple of years' observations that a gauge eight inches in diameter gives just as good results. Differences in amounts of rain collected by different gauges depend more upon other things than upon the diameter. We have adopted this gauge (sample shown). It is made of copper, the ring is carefully turned, and I think it is a very good gauge. This piece is put in to prevent evaporation. The rain is poured into this measuring tube, and is multiplied ten to one. That is, if we have one inch in the gauge we have ten inches in the tube. The cost is quite reasonable, only five or six dollars. There have been some alterations made in the gauge in the last year; and instead of having this wide scale we have this square one, which gives very good results. I hope if any of you are anxious to start a set of rain fall records, you will look a little into the subject of getting a proper gauge. This makes a very good snow gauge, because it is so deep. I found that one of my predecessors had been using a gauge, on the outside ring of which he had soldered a piece of tin, about half an inch beyond the ring, and carried it up abont a foot above, and he thought he was getting a very nice snow gauge out of it; but of course he was increasing the area by quite a perceptible per-

centage. I have not be able to find out exactly how many years that kind of a gauge was used.

On the Sudbury we have very good records indeed; the measurements have been carefully taken, and I think the figures as to the rain fall are quite reliable.

Having called your attention to the mean annual fall, 48 inches, and its fluctuations, let us now look for a moment at its distribution through the different seasons of the year. In the spring we have on the average 12.42 inches; in the summer, 12.83 inches; in the autumn, 12.33, and in the winter, 10.44. You will thus see that the spring, summer and autumn are very uniform in amount, but that the winter is somewhat below the other seasons. As you get back from the coast this seems to change somewhat, and a little further back from the coast all through the New England States, the autumn I think, as a general rule, gives somewhat more, and the winter almost always gives a little less than the other seasons. When you get over to the Pacific Coast the whole order is reversed; in fact, somewhat so in the Mississippi Valley, but for New England it is safe to say that we have about the same rain fall during the spring, the summer and the autumn, and in the winter slightly less.

It surprises most people who have not studied into the question to find how equally distributed the rain fall is. Taking the several months we find mean is as follows:

January,	3.60	July,	4.37
February,	3.41	August,	4.99
March,	4.22	September,	3.57
April,	4.16	October,	4.22
May,	4.04	November,	4.55
June,	3.47	December,	3.42

I have referred to the rainfall of 31 inches in 1883 as being the smallest rainfall we have had since we began making observations on the water sheds which supply the city of Boston. But there are records of smaller rainfalls. In 1846 Boston had 29.9; Waltham, 26.9; Lowell, 28; Cambridge, 30.4; Providence; 30.5; and in 1825 Lowell had 28.5, and in 1822 I find a record of 27.2 for Boston. After checking some of these records with other towns in the vicinity, I have come to the conclusion that we may adopt 28 inches for the minimum rainfall in the vicinity of Boston.

The available amount of the rainfall is the actual amount caught on a given shed, as measured in the channel or stream forming the main drain of the area. The rest or the difference between the amount running off and the amount falling is lost in different ways, but almost wholly by that great equalizer evaporation. In this connection it may be a surprise to some persons to learn that the evaporation from the surface of the ground in the course of a year is a very large proportion of the evaporation from an exposed surface of deep water. I have recently been looking into the matter of evaporation, and perhaps it may interest you to know that the approximate evaporation during a year, from a water surface is something like 35 inches. You see what an enormous loss there is by evaporation, and you see where all the water goes in the summer. In fact, after a heavy rainfall, if you examine into the matter, you will find, that a proportion of the rainfall comes up again even after it has gone down five or six feet

below the surface of the ground. It comes up again to be evaporated. So you see that it is very easily explained why we collect during the summer such a small percentage of the rainfall in the streams.

The mean yearly percentage collected on the Boston Water Works has varied from 25 to 60 per cent., depending on the distribution of the rain during the several months. The mean is about 42 per cent. This available amount of water collectible on any drainage area is the initial starting point for the designing of works for water supply, and it will be evident after a little reflection that it is not the mean amount collectible, but the minimum amount to which we must give especial attention, for it is the dry years, and the minimum collectible percentage, which form the weakest links in the chain, and therefore the true measure of our supply.

I suppose most of you are familiar with the trouble we have been through on the Cochituate works. The great difficulty with us all is to get the people in our different towns and cities to realize the importance of looking ahead. It is almost impossible to make people believe in the necessity of providing for the future. When the Cochituate Aqueduct was built a great many people thought the city of Boston would never be large enough to use the works to their full capacity, yet inside of ten years the Mayor had to issue a proclamation asking the people to economize in their use of water. For the ten years preceding 1872 it was a running fight to get an appropriation for an additional supply.

As illustrating the fact that the minimum and not the mean must be the guage of our work, if you look over some of the Parliamentary reports of Great Britain you will find that they have had a great deal of trouble in England because of the fact that the average flow of the streams and not the minimum was taken as their standard. A few years ago some of the larger towns there had to cut down their supply to twelve hours per day, and others had to cut down the consumption to seven gallons per capita. The brewers and manufacturing establishments were shut off altogether.

In 1880 we collected 12.5 inches, or 33 per cent. of the rainfall on the Sudbury, and in 1883 we collected 11 inches, or 33¼ per cent. of the rainfall. On the Cochituate basin, however, we collected only 10 inches of rainfall during both of these years, owing to the larger loss by evaporation, and other peculiarities of the water shed. These are smaller figures than have ever been taken as limiting a supply, and as they come from actual practice and careful measurements, the lesson is a most instructive one. The figures seem small, but if we examine the distribution of the rain carefully, I think we shall be warranted in coming to the conclusion that with a slightly different distribution during the summer months we should have had in 1883 as small a collection as eight inches.

But first let us see what available percentage of the rainfall is collected in the different months of the year, and we shall then get an idea of the effects of the monthly distribution. There are four months of the year when we may at least have little anxiety as to the available supply, viz., February, March, April and May. The mean for none of these months during the past ten years on the Sudbury River has fallen below 60 per cent. of the rainfall, and the mean for two is above 100 per cent., sometimes going above 200 per cent. Of course as the snow collects during

some winters and then runs off during the warm spring rains, we very often get much over 100 per cent., sometimes over 200 per cent. of the rainfall in the streams in the month of March. Then there are four months, July, August, September and October, when the amount of rainfall seems of little importance as affecting the yearly available amount for water supply, as the available percentage collected during these months is for a mean only 10 per cent., and has sometimes fallen as low as 5½ per cent. of the rainfall (1880.)

You must remember that I am speaking now of the available amount collectible, and not the uniformity of flow during the year, which is a very important matter. If we could have very large rainfalls in the summer and very small ones during the winter, we should have a more constant flow of the streams. This would be very advantageous for water works, but at the same time we would not have as large an amount collected during the whole year,—that is the total available amount would be very much less.

As examples showing how little the amounts of rainfall during the summer and early autumn months affect the question of the available amounts collectible in the course of a year from a given water shed, I have selected the following cases:

Month.	Rainfall.	Collected.
July, 1876,	9.1 in.	3.5 per cent.
August, 1878,	6.9 "	12 "
July, 1879,	6.5 "	7 "
July, 1880,	6.3 "	5 "
September, 1882,	8.7 "	6 "

For the general study of this subject, I should like to make a little different division in the months of the year from that made in the calendar and it will be something like the following:

First. Period from the middle of April to the middle of June, when there is great percolation and moderate evaporation.

Second. Period from the middle of June to the middle of October when the rainfall is of little importance and but a small percentage of it is collected.

Third. Period from the middle of October to the middle of December, a period of the greatest importance, especially where water is stored because then the water tables are filled and basins and reservoirs can be replenished somewhat from the flow of the streams if the rains are copious, as the percentages collectible amount to about one third of the rainfall.

Fourth. Period from the middle of December to the middle of February there is a good deal of snow generally. The water table does not get much of the water, on account of the frost but the collectible percentage amounts to about half the rainfall.

Fifth. Period from the middle of February to the middle of April when the percentage collected is so large that but little attention need be paid to the study of these months. The frozen ground being perfectly impervious to water, practically all that falls from the clouds during this period runs off into the streams or is evaporated, and the latter amount is of course small. The month of February is generally the first month that can be depended upon to fill completely those storage reservoirs, lakes, or

points which have been exhausted by heavy droughts during the second, third and fourth periods.

If the rainfall is small during the months of percolation the amount of rainfall collected during the succeeding months is correspondingly small. In 1880, the rainfall for May was but 1.1 inches, and that for June 2.1 inches. Although 15.6 inches fell during the next four months only 5½ per cent, of this reached the streams. In 1883 the same amount of water was collected from 10.5 inches of rain. I have noticed that if the rainfall is very large during the summer for one month, the per cent. of the rainfall collected during the next month will be considerable, but this does not seem to extend over more than one month, or at any rate not over a month and a half. From the middle of December to the middle of February a large proportion of the rainfall comes in the form of snow, the ground is frozen, and is as water tight as if a rubber blanket covered the surface, excepting, perhaps, in case of heavy woods; and this is where the forests come into play, for there the water will percolate to a considerable extent during the winter, while on the open ground it all runs off, or certainly does not reach the water tables. If the rainfall is heavy during these months, a very large percentage finds its way into the streams. But if the rainfall is in the form of snow, of course it swells the percentage during the spring.

As a general rule the larger the rain fall the greater is the per cent. collected. On the Sudbury River the maximum rain fall, 57.9 inches, in 1878, gave us 52 5 per cent. The minimum in 1883, 32.8 inches of rain fall, gave us 33.6 per cent.

In 1866 the rain fall on the Cochituate was 62.3 inches, of which nearly half fell during the four months of summer, viz :

July,	13.35	inches.
August,	3.98	"
September,	8.36	"
October,	3.43	"

Of these amounts 14 per cent. only was saved. The total available percentage for the year was 25.7 per cent., which was the smallest recorded on the sheds we are considering.

The following figures show the distribution of the rain during the summer months of 1883, when but 33 per cent. of the annual rain fall was collected at Lake Cochituate :

July,	2.4	inches.
August,	2.7	"
September,	0.7	"
October,	1.5	"
Total,	7.3	"

This was a very favorable distribution of the rain as far as the total available flow of the water shed is concerned. Had there been double this amount, or 14 inches in the four months under consideration, the 33 per cent. would have probably fallen to at least 25 per cent. for the year, which would have given us 8 inches instead of 10.

It is evident that we must come to a very dry year as being the weakest point in our chain, and that is about 28 inches. In 1868 we collected as little

as 25 per cent. of the total amount of the rain fall. If we should have with the 28 inches as unfavorable a distribution of the rain as we had in that year, in other words, a very large rain fall during the summer, and a very small one during the remainder of the year, we would probably collect only about one-quarter of this, which would bring us down to seven inches instead of from twelve to fifteen inches, which has generally been taken. This would reduce the water in the Sudbury River, for instance from about 40,000,000 gallons per day, for the minimum yield, to about 28,000,000, or something of that kind. Of course, this is, like everything else in nature, periodic. It is liable to come at any time; it may not come for a great many years. But it seems to me that it is a part of wisdom either to provide for it in the storage, or to decide to cut off some portion of the consumption during such an unusual year.

I do not know that there is anything more I desire to say on this subject, but if anybody has any questions to ask, I should be very happy to answer them.

Mr. Richards. I should like to ask the gentleman if he can explain why, when we sometimes get an inch of rainfall on our water shed, it does not raise our lake an equal amount.

Mr. Fitz Gerald. Well, I think it is very obvious from what has been said that most of the loss is due to evaporation. I do not presume you will say that in the spring of the year you would get a very small amount of the inch of rainfall in your lake. I do not know what your drainage area is, but in the summer season we get from two or three inches of rainfall less than we get from a quarter or a half an inch in the spring, when the ground is frozen. It is just as if a rubber blanket was spread over the surface of the ground, and the rain runs off into the streams and ponds.

Mr. Richards. The rain falls an inch deep on the surface of the water, I suppose, yet it does not raise the surface of the lake an inch.

Mr. Fitz Gerald. I have found that the evaporation in the summer from a water surface may reach six-tenths of an inch. The evaporation depends upon the atmospheric conditions. I have a self-recording instrument which plots the evaporation on a sheet of paper. I found an evaporation on the 25th of May last of 0.4 of an inch. We had had some showers in the early morning, and I could not believe the record was correct; but I figured it out from a formula, which will appear shortly in a publication of the American Society of Civil Engineers, and I found the theoretical evaporation was 0.381 of an inch, so the record 0.4 of an inch, was undoubtedly correct. You may have an inch of rainfall in the morning, and yet it will not raise the lake an inch. It depends upon whether you take your observations two or three times a day. Then I presume it makes a great difference how the lake is situated. I should fancy if you were satisfied from your rain-guage that you had an inch of rainfall on the whole area, and you took an observation immediately after the rain, you would find your lake had risen an inch, or very nearly an inch.

Mr. Richards. I have tried it and found it had not.

Mr. Fitz Gerald. Well, it is for you to find out what becomes of it. There is more or less evaporation during a rain, but it is not a very large amount, because the conditions are not favorable.

Mr. Sherman. I should like to ask Mr. Richards how long his lake is.

Mr. Richards. Two miles and a half.

Mr. Sherman. How many instances have you noticed in which a fall of an inch did not raise your lake an inch?

Mr. Richards. I could not say, but quite a number.

Mr. Sherman. Now, Mr. Fitz Gerald, do you not find that these storms frequently travel in very narrow paths, as you may term them? Mr. Richards may have found that an inch of rain fell at the point where he had his guage, but his lake is two miles long, and it may be that it was a narrow storm crossing the lake, it may not have been more than a quarter of a mile wide, so that there was not an inch of rain upon the whole area. That is the only way I see of explaining it.

Mr. Fitz Gerald. It seems to me if it rains an inch all over the lake it must raise the lake an inch, or very nearly an inch. We must always be very careful about the data.

Mr. Richards. It has occurred to me that the shores, being sandy and dry, might absorb a little by capillary attraction out of the lake itself.

Mr. Fitz Gerald. They probably do. We have found in filling up our lake from the Sudbury River that we have to run a much larger amount than the lake itself holds, nearly a third more in some cases.

Mr. Richards. Our guage is situated at the lake about six miles from the city, and in the city there is a station. I have often noticed it has rained at the lake, quite a heavy storm, when it did not rain in the city. That would tend to support Mr. Sherman's theory.

Mr. FitzGerald. Yes. Again, the slightest obstacle will produce very abnormal effects upon the guage. We have a rain guage on a raft, and there was a little house not a great ways from it, and I could not understand why I got such different records on the raft and on the shore. And I did not get them to agree until I took that little house awav. It made eddies of wind which affected the result materially. A rain guage should be exposed in a proper way in order to give good results, and it is necessary for us to be very careful in all our arrangements, if we would get reliable data.

Mr. Chase. Mr. Richards has undoubtedly demonstrated the theory that the farmers in the vicinity advanced when it was proposed to take that lake as a source of water supply. I happened to kmow something about the place at the time, and you could not find anybody about there who would believe that you could ever get the pond full, and Mr. Richards has undoubtedly found that to be the fact.

Mr. Rogers inquired as to the effect of elevation upon the rain guage records.

Mr. Fitz Gerald. I have been experimenting on that subject, but I cannot say I am ready to give any very definite results. It is certainly a fact that if you expose your guage a certain distance above the surface, you will catch less rain as you ascend. At a height of 20 feet, you will get 10 per cent. less than on the ground in the course of several years. And for that reason it is necessary to have a uniform system at all our water works. In the Meteorological Society we have adopted a foot as the best height. I do not quite agree to this, I should prefer to have a little more, but that has been adopted on the other side of the water, and so for uniformity the foot was taken as

the height of the rim from the surface of the ground. That does not allow much splash to get in, and it gives a pretty good result, except in the winter, when I think it is desirable to have a little greater height. If you put a rain gauge even three inches above the ground, and another one in a pit at the surface of the ground, you will get a little difference, amounting to two or three per cent.

There are all kinds of theories on the subject, and that is what I am trying to work out now. I am not ready to say whether the rainfall is actually less, or whether the fact is owing to other conditions. But it is a fact that if you expose your gauge at different heights from the ground you will get different results, the amount collected growing less as you ascend.

Mr. Darling. I would like to ask Mr. Fitz Gerald how high he would recommend having a rain gauge set above the surface of the ground.

Mr. Fitz Gerald. For the sake of uniformity I should recommend a foot, but I should prefer to have it two feet or two feet and a half. But as we have now in New England about 150 rainfall observers, where only a few years ago we had a very much smaller number, and as they all have their gauges, or are supposed to have them, a foot above the ground, as that is the height which has been adopted, I think it better to stick to it, for the sake of uniformity.

Mr. Darling. Ours is two feet and a half, I think, and I believe that was the recommendation made when we got the gauge. We have one of your Boston gauges of the old style, 16 or 18 inches across. It was recommended that it be put two feet and a half above the surface of the ground, and that is the position it now sets in.

Mr. Fitz Gerald. I think if you are faithful in taking observations, you will get very good results.

Mr. Darling. I think we do.

Mr. Fitz Gerald. I have one guage on the top of a building, at a height of 20 feet above the ground, and it gives uniformly 10 per cent. less than the gauge on the surface of the ground.

Mr. Ball. I do not know that I can enlighten the Water Works Association much upon the subject. I can simply state the result of a few observations that I have made. They have not been made with the care and precision, and have not extended over such a period as those which Mr. Fitz Gerald has presented to us. I consider his series of observations to be the most reliable and instructive of any that have been made in New England. I have several times had occasion to measure streams, carrying the gauging sometimes through a year, and sometimes for a few months, to determine the question as to the quantity of water that it was probable might be supplied from a limited area for the use of towns and cities. The first experiment with which I was connected was that at Worcester in 1863, where we had a limited area of 870 acres above the weir. I ran the weir carefully for 164 days, commencing, I think, the 5th day of May and ending in November. Unfortunately at that time I had no rain gauge near the weir, but there was one kept at the Insane Asylum for many years previous. I took the rainfall as observed in the city about five miles from where the weir was situated, and during that time we noted that about 48 per cent. of the water which fell upon the water shed during the 164 days passed our weir. After look-

ing over the various reports which I could find upon the subject, I concluded that the city would be safe in estimating that they could obtain 50 per cent. of the total rain fall; and subsequent events have proved that the estimate was within the range of probability.

On all the small water sheds that I have ever observed, Worcester, Fitchburg, Springfield and others, I have always noticed one thing about the collection of water, and that is that the real time is that stated by Mr. Fitz Gerald, some times from February until the middle of June, and some times it will be near the first of April, before there will be a large rise in the reservoir; and from the middle of June until the middle of October there is but little rain.

One thing has often occurred to me, aside from the matter of evaporation from the soil, which has been spoken of, viz: that there is another agent which lessens the amount which might be collected during the summer time, and that is growing vegetation. I have always noticed that the moment vegetation gets into full growth, which is about the middle of June, almost all small streams, and some good sized rivers, will begin to diminish, and they will continne at a low point until about the middle of October. I have observed several times that a considerable shower in the summer season will not perceptibly increase the stream. Take a shower during a dry season in the summer of 0.1 of an inch upwards to nearly half an inch, and in a few hours it is entirely taken up by the vegetation. It does not reach the streams at all but is entirely lost.

As to the amount which can be collected and used from any water shed, I think there is back of that one question more, and that is with reference to the opportunities for storing surplus water. Water must be collected when it rains, and stored for a time when it does not rain; and for that reason the larger a storage capacity is, the larger amount in the long run you can get from any drainage area. It is never safe to nearly or quite empty the storage reservoirs, for the reason that while this year may yield an ample supply, the next year may not, and the surplus of this year may be needed to carry into next. These are the observations which I have noted upon the works with which I have been connected.

Mr. Fitz Gerald. It seems to me, Mr. President, that this amount stated by Mr. Ball of about 48 per cent. agrees very nearly with our mean. But I do not know that I have made myself perfectly understood in my paper. It seems to me we should not take this mean to form our judgment upon, but we should form it on the minimum; and the minimum may run, with an unfavorable distribution of the rain,—that is, a large rainfall during the summer season.—in some years as low as 25 per cent. We have several cases where it has run as low as 30 and 33 per cent.

Mr. Ball. I accept the position of Mr. Fitz Gerald very cordially, and it is only in that connection that I suggested we are only safe when we have a surplus of storage capacity. If our storage capacity is limited, we may sometimes find ourselves in difficulty, if we have not taken as a basis the lowest possible per cent. of the amount collectible. A few days ago I was upon a water shed which I should judge might contain three square miles, and where I do not think they can safely rely upon over five per cent., because they have no storage capacity within the basin. The water runs off

the shed as it would run off the roof of a house down into the valley and out into the river and that is the last of it. For that reason they would not be safe to reckon upon anywhere near even the very lowest amount which drains off in the lowest rainfall. At Worcester the rain guage for about 40 years is about 46.95, I believe, a little less than 47 inches. At Springfield in 28 years it was about 46 1-3.

Mr. Fitz Gerald. There is one thing I should have stated more clearly, and that is that all these figures I have given are from a water shed of about 80 square miles, and they do not apply to larger water sheds, neither do they apply very well to smaller. That is, I suppose, in a smaller water shed we may get a less percentage, and the larger the water shed the greater the percentage generally collectible; and when you consider streams of the size of the Merrimac draining over 4000 square miles, the amount of rainfall collected may not go below 12 inches, I do not think there is much prospect of its going below that. So we have also to take into consideration the size of the water shed and its character, and I wish it clearly understood that these deductions are from a water shed of from 70 to 80 square miles.

Mr. Richards. I should like to ask Mr. Fitz Gerald if in the figure of 33 per cent. he has deducted anything at all for leakage.

Mr. Fitz Gerald. No, for the reason that our dams are supposed to be water tight. Of course there is a small amount, but it must be very small comparatively. The leakage from our upper basins only amounts to 200,000 or 300,000 gallons a day, and that is but a drop in comparison with the large figures. And from our lower dam the percentage is very much less, and there we catch all the leaks from our upper ones. Of course one of the *sine qua nons*, almost, is to get the foundations of your dam on an impervious stratum if you can, and if you cannot do that, to drive piling down to it, and prevent leakage under the dam.

Mr. Darling. We are now measuring by weir the drainage of an area of about six and a half square miles, and during the last few weeks, although there have been quite a number of heavy showers on the territory, there has been no perceptible rise on the weir.

Mr. Stacey. There is one thing I should like to ask an explanation of. If we have a pond, presumably fed by springs, with no stream flowing into it, with a small water shed, comparatively speaking, and we raise the water by pumping, will the pond fall with the springs, as we find it does in our wells? We have such a pond, and although we have had but a very short time for observations, we find that the pond will go down to a certain point, and then it seems to remain there, whatever amount of water is pumped. Some people claim that there are no springs but to me and many others the pond acts very much like some wells; being full, if you hold it, at the spring of the year, and then when the springs fall, whether you draw from it or not, gradually settling down to a certain point, and seeming inclined to stay there. If anybody here has had an experience of this kind, I would like to hear his views.

Mr. Fitz Gerald. It is a Yankee way of answering a question by asking another, but I would ask whether the time that the pond seems to settle down, as you say, to a certain level, is not towards the first of November, after you have got beyond the time of heavy evaporation, and when you get

a large percentage of rainfall? Of course a spring is not a mysterious thing, as it used to be generally considered. It is nothing more or less than the water coming in from the drainage area, and it all comes from the rainfall. There are cases where springs come from a long distance, outside of the immediate water shed; but those are abnormal cases, and the same rules that apply to a river and the drainage area of the river, apply to a pond fed by springs. It has its drainage area, and you can get only so much water out of it, depending upon the area. Of course, if the pond is fed by springs from a long distance, it has a larger drainage area than is accounted for on the map. But I think the gentleman will find, if he looks into it, that his measure is the amount he pumps, the amount he draws from his pond, and that is generally about the same year by year. When he gets down to where the percentage collected is large, then the pond does not go down any further; and of course, during the first part of the summer the opposite is the case.

Mr. Billings. I do not know as the thought I have in my mind will add anything to the point, but I will venture to suggest that in Mr. Stacey's case the surface water, in the spring of the year, raises the pond above what may be called the natural height of the ground water; that when he begins pumping, he draws the water off until the pond reaches the natural water table, the height of the ground water, and that he has never pumped so hard as to sensibly affect that, and for that reason has never lowered his pond below that point, If he were to persist in pumping with sufficient energy and for a sufficient time, he would find he could lower it, I think.

Mr. Fitz Gerald. Then follows, also, what Mr. Billings must have had in mind, that as you pump the water down you get a steeper slope in the water table, and so you get a greater flow. When you get down to that point, you absolutely get more water, because you are drawing with greater velocity through the ground. If the amount drawn is large, in comparison with the drainage area, you can draw your pond down, but not quite as fast as in the first part of the summer.

Mr. Stacey. We have found the lowest point every year to be reached about October. Except the point where the reservoir is located and one other hill there is no ground which is as elevated as the pond. The reservoir is 172 feet about the pond, which is considerably above tide water itself and is the highest land, I think, between tide water and Mount Wachuset; so if there is a spring the water must come from some distance.

Mr. Clark. I have been very much interested in the report given by Mr. Fitz Gerald, and I should like to ask him a question. For five or six years past I have been interested in observing a rain guage made after the description given by him in his report, having a diameter of 14.85 inches, and the directions, if I recollect right, were that it should be placed two feet and half from the surface of the ground. I have adopted the plan of weighing the water. Now, the questions that I wish to ask are these: First, why is it necessary to place the rain guage no less than one foot from the surface of the ground; and, secondly, what advantage is there in measuring the water by a lined scale instead of by weight.

Mr. Fitz Gerald. Well, sir, those are very easy questions to answer. Water is very uniform in weight, and by weighing more accurate results

are obtained than by measuring. It can be measured approximately by pouring the water into this tube; one inch in the gauge making ten inches in the tube, so if you get a little error on the scale, only one-tenth of that error is actual. But it is cheaper and easier for ordinary observers to measure with a stick, because all one has to do is to take this stick and gauge out and put the stick in and read it, and that is easier than it is to take your gauge inside and weigh the water. Weighing is more expensive, for you are obliged to have a scale, which costs several dollars. A weighing guage is rather more expensive than this gauge and not much better practically.

The gentleman probably had his directions as to placing the gauge before the Meteorological Society was formed, and there we came to the conclusion to adopt a foot, so as to have it uniform with the English practice and a good many of the gauges in New England are now so placed. I do not think it is at all necessary to alter these gauges from two feet and a half, but a note should be made of it when the record is sent in.

Mr. Tidd. I had not intended to say anything, Mr. President. I have had no opportunity to study these things as carefully as Mr. Fitz Gerald has. My business has generally been done with a rush, and I have had scarcely time for study. So far as my observation has gone it has agreed exactly with his experiments. It occurs to me that the fact he speaks of with regard to the rainfall being greater near the surface of the ground may be the result of natural law. All of us who have ever been familiar with steam engines will appreciate my explanation very readily. We condense our steam by injecting a shower of water into our condenser. Now the water starting from above the ground and falling, the natural result is the condensation of the water in the atmosphere below, and hence follows the fact that there is more water condensed near the ground than at any higher point.

In regard to the matter Mr. Stacey introduced, the pond of which he speaks is very high above the sea, some 350 feet, and it has a water shed which, like all other water sheds, supplies it with water through soil which is more porous in some parts than in others; and of course if he pumps the pond down to a certain level, where the slope is increased to such a level that the water flows in from all over the water shed, it will increase the flow to such an extent as nearly or quite to counterbalance his pumping. It seems to me there is no mystery about the thing. I have no doubt if he pumped long enough he would reduce it.

(Adjourned to 2.30 P. M.)

At 12 o'clock the convention adjourned to Library square, where steam fire engines Progress and Cornelius Howland were waiting to show the working of Acushnet water in the fire department. They were exercised about three-quarters of an hour. Each company laid two lines of hose of 100 feet each and the four lines were coupled to a union pipe. First with a 2-inch nozzle and only hydrant pressure, the water running through the engine pumps, the stream was played 84 feet 9 inches, steam was got up, and the stream was forced to a distance of 215 feet 7 inches. A 2¼ inch stream was played 198 feet 1 inch, and a stream of 1 3-4 inches was played to the distance of 253 feet 10 inches from the pipe.

AFTERNOON SESSION.

The convention was called to order at 2.40 P. M., President Coggeshall in the chair.

DISTRIBUTION OF SKETCHES.

Mr. Sherman for the Committee on Distribution of Sketches, made the following report:

We have not succeeded as well as we anticipated in the number of sketches which have been handed in for distribution; but we are holding our own, as compared with last year, and I think we have reason to congratulate ourselves. The committee have to suggest that in the distribution of these sketches, those who have contributed should be taken care of first, and after that the superintendents, for the sketches relate particularly to the work with which the superintendent is directly connected; and then, if there are any left—we have some 70 or 75 sets—they can go to the other members as far as may be. If that meets the pleasure of the Association, the committee are now ready to distribute them.

On motion of Mr. Hall the report of the committee was accepted, and the recommendation adopted.

The sketches were then distributed in the manner suggested by Mr. Sherman. The sets contained the following:

Edwin Darling, Pawtucket, diagram of daily consumption of water for 11 months; John C. Chase, Wilmington, N. C., table of meter tests; W. B. Sherman, Providence, foundation on quicksand; S. E. Grannis, New Haven, composite pipe; A. B. Drake, New Bedford, weir; W. H. Richards, New London, section of dam, showing action of anchor ice; R. C. P. Coggeshall, New Bedford, details of portable tool-house, two sheets; Frank E. Hall, Quincy, method of tapping wrought iron pipe, two sheets; Jonas M. Clark, Northampton, general plan of works and a number of devices in connection with street work; Nathaniel Dennett, Somerville, general plan of works; Edward H. Phipps, New Haven, dam built for West Haven Water Co.; D. W. Horan, Clinton, break in twelve inch main in ledge; William R. Billings, Taunton, main pipe plugs.

THE PLACE OF MEETING.

In response to an inquiry by the President, the Secretary stated that the Association had received no invitation to hold its next annual Convention in any particular place.

Mr. Walker. How will it do to come up into old New Hampshire next year? (Applause.) If that suits we will try to entertain you.

Mr. Darling moved that the Association hold its next annual meeting at Manchester. The motion was adopted by a rising vote.

ADDITIONAL APPLICATION FOR MEMBERSHIP.

The Secretary read the following names of applicants for membership, stating that, as required by the new constitution, the applications had received the endorsement of two active members, and they also had the endorsement of the executive committee:

William Rotch, Civil Engineer, Boston; John B. Brady, Commissioner,

Worcester; Charles A. Allen, City Engineer, Worcester; William Hancock, President, Trenton, N. J.

W. H. Foster of the Whittier Machine Co., Boston, was elected an associate member.

On motion of Mr. Horan the Secretary was instructed to cast the vote of the Association for the gentlemen, which the Secretary did, and the President declared them to be elected members.

Mr. Darling. We have with us here to-day a gentleman whom we all know, perhaps not personally, but by reputation, a gentleman who is a co-worker with us in our labors, and one who has published more statistics in regard to American Water Works than any other man—I allude to Mr. George H. Frost, the editor of the *Engineering News* of New York. And as a token of our esteem for him, I am directed by the executive committee to recommend his election as an honorary member of this Association, and I move that he be elected as such.

The motion was adopted.

Mr. Frost. I am very much obliged for the honor you have conferred upon me. While it is true we have collected and publised a great many statistics. I do not personally know that I have any great knowledge about the inner workings of Water Works, except in a general way. I have been acquainted, I may say, with most of the people who are here, a good many years, and it has given me a great deal of pleasure to meet you all here. I am very much obliged for the honor which has been conferred

The President. We come now to the reading and discussion of papers, and I have the honor of presenting to you Dexter Brackett of Boston, who will read a paper on

WATER WASTE.

[Mr. Brackett's paper would form one of the most interesting and valuable parts of these proceedings, but for the fact that it was read from notes, and that the author's regular duties have given him no time to prepare the matter for publication. We hope to present it in some future issue.—EDS.]

DISCUSSION.

Mr. Hancock. The problem of the waste of water is not only one of the most important which we have to consider, but, I think, one of the most difficult to solve. We can make our calculations about reservoirs and pipes very accurately; but the problem of waste has so many unknown quantities that in considering it we are completely lost. Mr. Bracket tells us that the consumption of water ranges from 25 to 26 gallons per capita up to something over 100, but we are satisfied that it is not necessary for people to use that large quantity of water. It seems to me that 40 gallons per capita, certainly 50 gallons, should be sufficient.

Then the question comes up at once, how shall we stop this waste? I admit that a general introduction of meters will reduce the waste of water to a minimum. So will inspection, if we inspect often enough. To metre a city like New Bedford or Springfied will cost approximately something like $100,000, and then they must be maintained, which certainly will cost something. If we call it ten per cent., there is $10,000, and then

the interest on the plant of $100,000 would be something like $4000 more, making a total of $14,000 or $15,000 a year which it would cost a city of the size of New Bedford or Springfield.

Cannot we accomplish the same thing for less money? It seems to me that we can. We can inspect or we can use the Deacon metre, which is a good thing, and which accomplishes a good deal. The question occurred to me, why is it necessary to go about in the night trying every stop-cock in order to find a leak? Why not go into the house in the first place? Place a rod on the pipes anywhere, and you can tell whether or not there is a leak. There may be cases where I should be in favor of applying metres, but it seems to me that more can be accomplished by a close inspection.

A great many people in our city seem to have the impression that a municipal law covering the use of water cannot be enforced. I do not know why it is that people think so. We have ordinances that say sidewalks shall be cleaned, and they are enforced; but to neglect the sidewalk will not do a hundredth part of the damage done by wasting the water. According to Mr. Brackett, one-third of the water that we introduce runs to waste, and I see no reason why we cannot enforce rigid, just, equitable rules in regard to this matter. It will not do to whisper to the people, that they must obey them. You must enforce them strictly, and if the law is violated find the violators. Then if the people do not like it and prefer to have the water wasted, let them pay the fiddler, that is all. But I think that the people as a whole want this great waste stopped, and if they do, all they have got to do is to pass proper rules and regulations and say to the superintendents and water registrars: "Go ahead and stop the waste and we will back you up," and it can be done.

I have not figured the thing carefully, but I have the impression I can visit every house once a week for less money than I can put on metres, and it seems to me that would be a pretty close inspection.

The President. As the paper by Mr. Taylor, which is to be presented this afternoon, on water metres, seems to be in the line of discussion, I will take the liberty of asking the Secretary to read it at this time, and then both papers can be discussed together.

The Secretary then read the following paper by Mr. Lucien A. Taylor:

WATER METERS.

This subject has been discussed to some extent by this Association, and much more by the individual members of it; in fact, there is no subject of conversation more common than that of meters, and there is room for much more profitable discussion in the same line of thought. Having recently consented to write a few lines upon this topic, and without previous preparation at an unusually busy period of the year, this paper will simply serve to introduce the subject, and open the way for valuable discussion and information by the members of the Association present. The first requisite of a meter is accuracy and reliability. Be it ever so strong, well made, or handsome in design and finish, if it has not these qualities, it is of no use to a water department or company. I have never yet seen a test of a certain type or kind of meter that seemed to me to be all a test should be. That is, they are usually made by running a large amount of

water through them in a comparatively short period of time, and that meter which shows the best registration and least wear at the end of that time, is adopted. While this may in most cases be the only test, or the best one that time will admit of, and will establish certain facts, there are other essential facts it does not establish. I think, in fact, that most of those in use to any extent, will pass the normal amount of water, and register it with reasonable accuracy. To determine whether a meter is accurate through all stages from its infancy till worn out in the ordinary way of using them, would require a series of experiments and tests, covering a number of years. A few months ago, I commenced some experiments and tests in a small way on a number of meters attached to my house service, reading them every day with the intention of continuing for an indefinite length of time. A change in situation obliged me to discontinue the experiment. Although designed simply for my own information, it was quite interesting, and I believe many of our members would gain much valuable information by trying it themselves for a series of years.

As it occurs to me now, I will say a word in regard to loss of head by the use of meters.

My experiments were few and were only preliminary to what was intended. However, I will state a few facts that may be interesting, and lead some of our members to make thorough experiments for themselves. I attached twelve of the ordinary house meters, that is, 1-2 and 5-8, of various kinds, beyond the meter already in use and the water used in the house passed through all of them. These thirteen included seven piston, meters, viz: Ball & Fitts, two; Desper, two; Duplex, two; Worthington, one; and six with the rotary movement, three Union Rotary, two Crown, and one Empire. All were new except one Union Rotary, that had been in use five and one-half years and had never been opened or repaired. A pressure gauge was placed at each end of the line, the pressure standing at 60 pounds. The application of so many meters made the loss of head quite noticeable in the house, but not so much so as to be very inconvenient. Upon opening a faucet on the second floor above, at a basin, the pressure would be reduced to fifty on the inlet, and forty on the outlet end of the meters. If a sink faucet nearly on a level with the meters, and say fifty or forty-five feet away by the line of pipe was used, the pressures were reduced to forty on the inlet, and about ten to fifteen on the outlet.

A trial at the shop was made. The pressure standing at 78 to 80 pounds. A mean of three trials of five minutes each was made in all cases. The water being weighed in a tank.

With a half-inch outlet and no meters on the line, the discharge was 21.36 gallons per minute. Upon applying one five-eighths Union Rotary the discharge was 96 per cent, of the above amount. With twelve Rotary meters on, the discharge was 62.3 per cent. With one five-eighths Desper meter it was 79.4 per cent., and with five Desper meters, 46.9 per cent. With an opening of two-tenths of an inch at the tank, the discharge was 6.66 gallons per minute. With the application of one Union Rotary, it was 99 per cent. as much. With twelve Rotaries, it was 93.2 per cent. With one Desper meter, 95.3 per cent., and with five Despers, 85.1 per cent, These were all new meters that were on the bench being tested. Had no time to try other kinds and sizes as had been the intention.

It will be seen the loss of amount and consequently loss of head, was very slight with the Rotary and, as might be expected, considerable with the Desper or piston meter.

I know there exists in the minds of elevator and motor men a great prejudice against applying meters where their machines are in use on account of the loss of power.

I believe this loss is very slight, as a rule, so slight, in fact, as to be discarded in any calculation as to the effect on the motor or elevator. I also suspect it is in many cases very desirable to have the amount of water it takes to run a motor an unknown quantity; as it does not agree with the expressed calculations of the agent as to the amount necessary to do a certain amount of work. I think I should always feel much better to have a meter on than to assess by rates.

Upon the question of the application of meters generally, upon any system of water works, while it is true every one should pay for what water he has and nothing more, it is also true in the management of water works that circumstances in different places are so different that no general rule will apply, except to a certain extent. For large consumers, it seems to be the only just and feasible method of assessment; and even then, in many cases, the cash value of the water is of only secondary importance, as it is the policy of the city or town to encourage business enterprises, and the low price at which water can be obtained is one of the inducements held out to parties to locate or enlarge their works and they want all the water they choose to use or use and waste, for a certain fixed price regardless of quantity so used or wasted.

If the people choose to be taxed for the support of their water department it is their option to do so. In the case of a private company, the case is different, as they must get all the money out of the works possible, and must manage them with that end in view. For domestic uses, from which, as a rule, the greater part of the revenue is derived, if water is plenty and has simply to "run down hill," it is the easiest way to let people pay their rates and use all the water they want, and waste double what they use. But when the time comes, as come it must very soon, that the supply is short, or if the supply is ample the capacity of the pipe system is exhausted, people on the high grounds complain of a lack of pressure the efficiency for fire purposes is impaired, and the question arises how to remedy the evil. An estimate is made for an addition or increased supply, or for an additional main pipe line. Either estimate is very large and the water works officials cast about for some cheaper method of solving the difficulty. They naturully turn their attention to meters and it may be, put them on universally. If they do, I think they will make a mistake. There will be a large expenditure for meters and although the reduction in the amount of water used is large, the reduction in revenue is still larger, and at the end of the year there is a large balance on the wrong side.

I believe meters should be applied, but with discrimination, so as to effect a reduction in waste without affecting the revenue to any extent, and I believe it can be done. By placing meters upon the largest consumers and where there is the greatest waste, a step will be made in the right direction. At the same time, a thorough inspection should be made of pipes

and fixtures, and people thoroughly informed of the necessity of checking waste. Of course the truth of these remarks will depend very largely upon what the faucet and meter rates are.

As the greatest amount of revenue is derived from domestic use, so is the greatest aggregate waste from the same source. And in this connection I will say there is too great a discrepancy between faucet and meter rates for domestic use of water, either faucet rates are too high or meter rates too low. The latter, I think, is true. In my own case the faucet rates would be twenty-six or seven dollars per year. We use water very freely, more than is really necessary, and the meter rate is about nine dollars per year at twenty-five cents per thousand gallons or one hundred gallons per day. I know a great many tenement houses and residences where the meter rate is from one-sixth to one-fourth the faucet rates and this is no fault of the rates. We all know how difficult it is to change or at least increase meter rates. In my own case, as the meter has been in use six years and never taken off for repairs, I fancied I was getting a large amount of water for nothing, much of it being run into a tank; my impression was about twenty or thirty per cent.; an investigation proved the meter run nicely on three-hundredths of an inch stream.

So I concluded I was paying for about all the water I used.

The application of a meter should be within the option of any taker if he choose to pay for it, but the department or company should be protected by a suitable minimum rate to pay for the reading and incidental care and expenses attending the same.

There are some places where meters have been applied indiscriminately, and a large reduction in income was the consequence. Upon discovering that they had been to heavy expense for meters with the above result, the water works officials have condemned the whole meter system, and wish they had never applied any.

The real trouble, however, is they have not used good judgment in the matter. Let each superintendent or manager of water works study the subject from his own individual standpoint and his circumstances and surroundings, institute tests and experiments for himself, in short, put as much brain into the subject as he does into any other branch of his work and he will be enabled to apply meters in such a way and to such an extent that it will be a benefit to the consumer and to the business of which he is the manager.

Mr. Clark. I heard some very interesting statements a few days since of certain facts with regard to the city of Atlanta, by Mr. Garrett who is now present.

Mr. Garrett. Last year when in the city of Atlanta I was informed that the condition of the water works was such that they would have to introduce a more extended pumping system and a 20-inch main. They were using the Holly system and with 125 pounds at the pump they were seldom getting 25 pounds on their main, and in consequence of that a very large expenditure for extension of water works would be required. Sometime after that I went again, looking up the 20-inch main, and was informed they had discovered the remedy. An ordinance had been passed by the city which required each water taker to put on a metre and pay for his water according

to the amount delivered so that they had entirely overcome the difficulty by arresting the waste of water, and they now have plenty of pumping facility and need no further extension of pipes. I was also informed that the meter system was entirely acceptable to the inhabitants, and was working satisfactorily. This in brief is what I told Mr. Clark.

Mr. Tidd. Can the gentleman give us any information as to the cost of that saving. Possibly the meters to accomplish that result cost more than the 20-inch main would have cost.

Mr. Garrett. That might have been. I did not go so closely into the subject, but it is probably in the report.

The Secretary. I might state that Mr. Howland, who was here yesterday, told me in conversation that they had put on meters, and that the year following their introduction their receipts were larger than they had previously been.

Mr. Garrett. That is my recollection of it, and I think the superintendent told me they had really lost but very few consumers.

Mr. Tidd. That reply does not cover my question entirely. What I wanted to get at was this: Whether the expense of these meters did not exceed what the cost of the new main would be. Of course they were put on at the expense of the consumer, but whether paid by the consumer or by the city, a certain amount has been expended and that of course should be taken in the aggregate. The gentleman says their receipts were larger, but their meter rates and service rates might have been different from ours.

Mr. Hancock. If it costs the people of a city $100,000, it does not make any difference whether you raise it by taxation, or whether the people pay it directly. Perhaps if raised by the municipality it would be distributed more equally.

Mr. Rotch. This question of stopping the waste of water is a much more important one than most people have, until lately, considered it to be. It really has only occupied a prominent part in the consideration of water companies for ten or fifteen years. In fact the introduction of water, except into the larger cities, is hardly more than a generation old, and people have not yet realized the importance of saving it. Water is not entirely unlimited in its supply, and we are going to find that out sooner than most people think. Already cities, both in New England and all over the country, are discussing the question of going further and further for their supply. The supplies are limited to a certain extent, and will become more and more so as the forests are cut down. The time will come, and it is not very far distant, when cities will have to make the best of what they have close at hand. They are growing in population, and are so close together that before a great while they will be fighting for their water supplies. Then it will not do to say that the problem is to be solved by the placing of larger supply mains, for there would then be danger of exhausting the whole supply. I believe the only true policy is to educate a city from the beginning to the economical use of the water, and I do not think there is any better way than that of an inspector on every house, and no inspector will watch so carefully as will a meter. It is impossible, as one gentleman has suggested, to inspect every house once a week, unless it is in a very small village. Provided you could do it, the inspector is in the house but a few minutes one day in the week,

and how is he to know what is going on the rest of that day and during the other six days? People are very shrewd in these matters, and will soon find out at about what time the inspector is due, or they will perhaps run the risk of being discovered once or twice. And then again, the greater part of the waste takes place during the night.

I remember five or six years ago Mr. Brackett prepared a very interesting set of diagrams, showing the consumption of water in a number of cities during the different months, and during different hours on different days. It was a very curious fact that in many cities, the greater part of the waste took place during the nights and in the winter months, just at the time when the consumption of the water should be the least. Now, why is that? In the winter, of course, no water is used for watering the streets or sprinkling the lawns, and the general consumption ought to be 50 per cent. less than in the summer, yet it is greater. The diagrams show that it is during the night that the water is wasted in the winter months. That is to say, people instead of taking the pains to protect their pipes from the frost, will let a small stream of water run and that counts up very fast, as they will find out if we apply meters.

Now the first cost of meters and the expense of maintenance has been very much exaggerated. I have had a good deal of experience in this matter, and must say it has been very favorable to their use. There is in Fall River a larger per cent. of service pipes metered than in any city in the country, except Worcester, and the result of the application of that large number of meters in Fall River, and, also, in Providence, where the percentage is almost as large, has been very favorable. The facts show that the waste is best prevented in cities having the largest number of meters. The cost of maintenance is trifling. Instead of being 25 per cent. or 10 per cent. of the cost, it is only one or two per cent. Any one of the half dozen or more of the most reputable makes of meters, showing the greatest amount of error, are preferable to any other system.

Mr. Brackett. Perhaps the gentleman may have misunderstood me as to the cost of maintenance. I meant to state, and I think I did so state, that the 12 per cent. included not only the cost of maintenance, but the depreciation in the meters. There may be those in use to-day, the average life of which will be more than eight or ten years, but there have not been in the past. I think, that, an estimate placing the average life of the meter at from eight or ten years, and allowing for the cost of repairs and the cost of the maintenance, in which I include the reading of the meters, from ten to twelve per cent. is not excessive.

While I believe in the use of meters, on the large consumers, perhaps on 20 per cent. of the services in Boston, I think the bulk of the household service, can be controlled in a much more economical manner. The cost of the inspection will probably not exceed $20,000 per annum for the city of Bostoe, while the interest and depreciation on the meters would be at least $200,000. There is difference enough there to cover considerable between the two systems.

In regard to Mr. Hancock's suggestion as to whether it would not be just as well to visit every house often instead of putting on meters, I would say we have found that in a great many sections of the city there is a very small

amount of waste. In some sections the first inspection of the meter indicated a night comsuption of three gallons per capita, and while there were others where it was thirty. For an inspector to visit every house in a section where there is but three gallons wasted would be time thrown away. The visiting of houses in the day time and listening on a pipe, is of no practical value, especially in a large house, or where there are a number of tenants, for if the water is found running, it is not necessarily being wasted. In the night you are reasonably sure the water is being wasted if you find it is passing through the pipe. And then it would take more time to go into the houses and inspect the plumbing during the day time, than it does to make your tests at night.

Mr. Fitz Gerald. Whatever method is taken to restrict waste, I think it evident to all who have spent much time in studying the question that it must be done, not only for an economical distribution of the water, as my friend from Fall River states, but also from a point of justice. It costs something to deliver a gallon of water at the faucet, and we should treat it exactly as any other commodity. It is of no use to increase the capacity of the works, and spend large sums providing additional supplies of water, when the consumption is continually increasing in proportion. Evidently it must sooner or later be stopped, whatever process is adopted to accomplish that result. And the sooner it is done the better.

I think, perhaps, in the matter of meters, the city of Boston has been a little more unfortunate, so far as I have been enabled to observe, than some other cities, and I should think it would perhaps be well to take the experience of Fall River and Providence. They have been very successful in Providence, and have got a very remarkably low consumption.

The injustice of this matter of waste was illustrated to me last winter by a friend who has a very handsome house, which is very finely plumbed and everything is in perfect order. He went away duriug the winter and was gone a couple of months, and his wife regularly, every night, opened all the faucets in the house and let every one run, because she was afraid something might freeze. I think a good deal of that sort of thing is done. In the house to which I refer nothing would have frozen but that was her idea, and so she wasted all that water, and I leave you to imagine how much there was wasted during those two or three months.

Mr. Stacey. There seem to be so many sides to this question that it is hard work to grasp them all. The circumstances in almost every locality are different. With a gravity system of ample capacity for the present, it seems to me the more liberal they are, the more money there is in it. But where you have to pump it, every gallon represents a certain commercial value. With a house to house inspection the difficulty seems, as has been suggested, that the water is stopped for the time, to be again renewed perhaps in five minutes after the inspector has left. How are you to prevent the people from allowing the water to run all night long to keep the pipes from freezing, by a house to house inspection? You might go out yourselves, and perhaps freeze in doing it, and detect two or three; and then, out of revenge, they would try to get the best of you by wasting all the water they could.

Now, in our place we have a good supply, and we are piped large enough to give the town every drop of water, in my estimation, that the lake is

capable of furnishing. When that gives out we will have to go from four to six miles for our supply, and will have to raise it about twice as high as we now do. Then the question will come to the town of Marlboro, whether it is not better for them to put in meters reducing their consumption and making it possible for the present supply to be equal to the demand for years, than it is to go to so much additional expense just for the sake of giving the people plenty of water to waste.

As I look at it, every man wishing a meter and willing to pay both for it and its maintenance should have one. In certain places I would advocate the placing of meters by the town. One place especially is a livery stable. It is enough to make a man's hair stand on end sometimes to go into a livery stable and see them put on the water. (Laughter.) And it is just the same with a laundry, a bottling establishment, and all such places; they have no more idea of the commercial value of water than if it ran into the roof of the house by gravity, without any expense at all or any exertion whatever by anybody. As we look into the future and see all the little towns taking up their water supplies, can we not see the time not far distant when water is to be very precious, and shall we not want to hold on to every drop? I do not think we have started the agitation of this question any too early. The time is coming when it will be forced upon us, and we shall be obliged to take some action.

Another point in regard to meters is this: If a man knows he has a meter in his cellar and the water is going through it, even if it does not register accurately; is it not a monitor all the time admonishing the man to be careful, or his bill will be too high? And does not this strike him in his pocket, the tenderest place to strike almost any man, in this country or any other? (Laughter.) As I look at it every locality should decide for itself, according to its own circumstances; but by and by the time will come when all of us will have to stop this waste or go without water.

The President. We have a friend here to-day whom we all know, and I know we all would be very glad to hear from him. I refer to Mr. Walker of Manchester, N. H.

Mr. Walker. No, I thank you, gentlemen. (Laughter.) I prefer not to say anything, for there are many others here who can talk so much better than I can. (The convention applauded and insisted that the gentleman should proceed.) This is simply done for effect because I have asked you to come up to Manchester. (Laughter and applause.)

Mr. Hall. My experience has been that for domestic consumption the general use of meters increases the expense of collections and decreases the revenue. That point has to be met in a majority of cases either by an increase of the specific sum to be paid in all cases, or in some other way; or else, as has been stated, there is a great discrepancy between schedule and meter rates. For manufacturing establishments, livery stables and such places, I think the only equitable way of furnishing water is by quantity in the same manner that any other commodity would be sold. The majority of people find it hard to acknowledge that water has a value. I consider that there is a value to water higher than is given it when we say we will deliver it at a certain price per 1000 gallons. It is not only a necessity but a luxury: and I think these things are not considered enough in establishing a schedule of rates.

Mr. Holden. I understand that there have been about 600 water meters patented in the United States, and of these, from what I can learn from the various water reports not over six are now in general use throughout the country.

Probably every person here who has charge of water works has had frequent visits from agents or inventors of the "only reliable water meter ever constructed," and which is eventually going to supercede every other meter in existence. They ask for permission to send a sample meter, request that it be tested in every way possible, and if it proves to be as represented, which they have no doubt but what it will, they modestly ask to have it adopted to the exclusion of all others.

Now every superintendent here is doubtless anxious to get hold of a perfect meter; and the question that now arises is, what is the best method to test a water meter in order to find out its good qualities and whether it is adapted for general use under all circumstances and in all places.

There are some cities which have a very elaborate apparatus for testing meters. They have a wrought iron tank set on delicately adjusted scales with a thermometer for registering the temperature of the water. A hydrometer for determining the specific gravity of the water, and a barometer for observing the density of the atmosphere while the tests are being made. Also a pressure gauge and a stop watch are considered necessary.

Another way to test a meter is by attaching it to a drinking fountain or other continuous stream, and letting it run incessantly until several thousand gallons have passed through it, and then, if on examination, the meter is not worn out, to publish the amount of work done, and show that for durability it is ahead of anything else in the shape of meters.

Now I claim that water here in New England is too cheap to be measured by drops, and that there are no works represented here, but what can afford to throw in a few extra gallons for each thousand registered, provided that the meter is practically correct.

Hence there are other qualifications more necessary in a perfect meter than extreme accuracy; and as regards durability, every mechanic knows that a continuous equal strain on any machine is not so wearing as an intermittent one.

Take for example, a locomotive running on a uniform grade at a regular speed will wear much longer than the same one would on an uneven road.

The life of a switch engine is not one-fourth as long as it would be if running regular trains, and for the same reason the best water meter may not be the one which will register accurately every drop of water which passes through it. Neither will the one which can run a continuous stream without wearing out always prove to be the best for practical use.

Now is there any better way to find out the good or bad qualities of a meter than to put it in connection with the best standard meter known on to a service where a large amount of water will be used intermittently, and then after several months use with occasional inspection, some idea may be formed as to which meter is the best.

I have been experimenting for some time past in this way, and so far I have about come to the conclusion that there are no two meters in existence which will register exactly alike under all circumstances.

Perhaps some of the meter manufacturers here can enlighten us as to their manner of testing meters.

Mr. Chase. There is no doubt but that a large reduction can be made by a house to house inspection; but I think a majority of the water consumers would object to a weekly inspection as a nuisance. One disadvantage is that the innocent suffer with the guilty. I have been a strong believer in the equity of water meters for a long time. I have arrived at the point where I think with domestic supplies it is better to have either all meters or none. Take an ordinary works where perhaps one-quarter of the consumers are using meters, and I think you will find generally, that the parties who use the meters pay a much larger rate per 1000 gallons, than those who do not.

There is another point in regard to the waste of water bearing upon gravity works, as well as upon works constructed where pumping is used. It is not always a question of whether water can be got at a sufficient height in order to furnish it by gravity, but it may be a question whether the extra capital required to get it by gravity would not represent more than the capital required to furnish it by pumping. Therefore I think the meter question is a fair one for gravity works as well as for those which pump exclusively.

I believe the department should own the meter, whether the city or a private company owns the works. I may say, in justification of selling water by meter, that I do not know of any other natural or artificial product that is sold in such a loose way as water. I cannot compare it with anything better, perhaps, than charging a man board according to the size of his stomach or the size of his mouth. (Laughter.) But when it comes to the question of furnishing a meter, why should the consumer be obliged to buy a meter, any more than to pay his share of the cost of other portions of the works? If we oblige him to buy his meter, why should we not oblige him to chip in at the beginning and pay his proportion of three-quarters of the expense of the works, or that part of the expense of the works that belongs exclusively to domestic consumption, allowing that a quarter or a third of the expense of the works should be charged to fire protection?

If the department owns the meters, it can determine which is the best for its purpose, and have better control over their operations. It would certainly afford the consumer opportunity for criticism, if, after allowing him to buy a certain kind of meter, the department should become dissatisfied with it and should oblige him to repair it at great expense or to discontinue it altogether: I think, however, the question is worthy of consideration whether there should not be a change made in the dials from feet to gallons; and if found expedient the Association should take such action as would bring the meter companies into accord with it on that question.

Mr. Dennett. We have with us Mr. Nevons of Cambridge, a city where they have had a house to house inspection for many years, and where there are less than 200 meters in use, I believe. I think the Association would like to hear from him.

Mr. Nevons. I did not mean to say anything here to-day, Mr. President. I came for the purpose of listening to the papers and to the discussion upon these questions, especially the question of waste. I do not care much

about meters. There has been a great deal said about inspection, but there is one feature of it which has not been mentioned here which I consider very important. My idea of inspection is to shut off the main pipes at night, and then by means of the sidewalk shut-offs, find if there is a leak in the section under examination. This is done by the sidewalk wrench and a leak can be detected just as nicely as if Mr. Brackett's Deacon meter were applied. I did that within three weeks on a large section It is not necessary to send the day inspector into houses except those where leaks are discovered. I thoroughly believe in a house to house inspection, and with the right man a wonderful work can be accomplished. I know we have done so in Cambridge. In one year we reduced the consumption about 400,000 gallons, and it did not cost the city $100 extra. To be sure, I did the night inspecting of the mains myself, taking large sections. During the following day the inspector went to the various places where leaks had been discovered.

I have never seen anything of the nuisance of a house to house inspection that has been spoken of.

I have never known but one case in my nine years of experience where the inspector was not allowed to go on the premises, and in that case I did not blame the people in the house for we found they had one of the worst leaks we ever saw. An inspector should be a gentleman, should have his work thoroughly at heart, and should be well paid for his services; such a man the consumers would gladly welcome. (Laughter.) One of the hardest things to control is the waste of water in cold weather, for people will let it run to prevent freezing, but I think by good thorough inspecting you can reduce the consumption and keep it where it belongs. We have 194 meters which have been placed on large manufacturing establishments, but I should endorse house to house inspection every time, for I believe in it heartily.

Mr. Fitz Gerald. Can Mr. Nevons give us any figures that will help us form any opinion about what that costs compared with other systems,—for instance, about how many inspectors for a certain area?

Mr. Nevons. I can only state in a general way. We have about 100 miles of main pipe. About three months a year we hire an extra inspector. We have one regular inspector who attends to the reading, and does the general work of the water registrar, hunting up cases, and so on; and the inspection has been done with our general work, with the exception of hiring a man about three months a year, as I have said. I have done the night inspection myself, so that that has been no extra expense to the city.

The Secretary. I would like to ask Mr. Nevons how often that inspection is made.

Mr. Nevons. We have always intended to make it once a year all over the city. We have learned now that if our consumption goes up, it is likely to be in certain territories, and we know pretty near where to look for the trouble. It is usually found in our marsh territories. Last year I did not do any night inspection except in what is known as the East Cambridge territory, which is low, marshy ground. The canvassers have instructions when they go around to get the fixtures, to see every fixture in house, so that when the canvassing is done every fixture is inspected; and in the fall of the year we usually begin on the general inspection.

Mr. Schleiter. I do not agree with Mr. Chase in believing that those who have no meters pay much less than those who have meters applied. My experience has been far different. We have adopted the meter system for large consumers, and have now used it for five years. Previous to that time we received between $5000 and $6000, but since have received between $11,000 and $12,000 from the same parties. If I were working in the interest of a private water company, I think it would be profitable to place meters on all large consumers, but not on to the small ones. I believe the cost of inspection, care, interest on the cost of the meters themselves, is more when applied to small consumers than the saving.

Mr. Hawes. I am a meter man, and I believe in meters. We have some 2600 meters in operation in Fall River, and find them a great check to the waste of water, and I think our rates per capita will average below most cities, being only about 26 gallons. Mr. Holden tells us there are 600 different patents for meters in this country, and it seems to me that there are just about as many sides to the question as there are meter patents. I am satisfied from the discussion that has taken place here that there are no two places alike. Mr. Nevons tells we ought to educate the people not to waste water. Mr. Nevons has, I suppose, the very best place in the United States for the inspecting system. If he wants to experience something of the difficulty of educating the people in this direction, let him go into a manufacturing town and undertake it, and if he won't have a good time doing it, I will give it up. (Laughter.) While he has a good place in Cambridge to use the inspector system, we have a good place in Fall River to use the meter system; and so the thing will vary in different parts of the country. I do not think a perfect meter has yet been invented. I think it will be like the perfect man; just as he gets perfect he up and dies. (Laughter.) When a perfect metre is invented the millennium will come, and we shall not have any use for them. (Laughter.) I think this little piece which was published in the Boston Globe last Sunday comes pretty near the facts. This meter was sitting alone in the cellar, and it saw an interviewer coming, and it made the following remarks :—

THE WATER METER.

[J. B. Laying in San Francisco Wasp.]

I'm a wicked water meter, a Pharisaic water meter, with a face of white enamel, hard enamel, trimmed with brass;
But I wear the soft expression of a painted Simon Peter looking out into the future like a goldfish through a glass—

Click!

As a patent fact-distorter and a shameless story-teller I can beat a circus-poster or a stable auctioneer;
For I grind such tough narrations in my corner in the cellar you may scrape a Beadle novel from the members of my gear—

Click!

Should the people rise and clamor, loudly clamor for reduction; should the board of supervisors fix the water rates too low.
By a esoteric hammer, most ingenious in construction I proceed to raise my figure in oposing rati-o—

Click!

But I rarely, very rarely, need to exercise this power, for the board and my employers keep the water rates secure.
O, they cuddle close together, just like chickens in a shower, and they yank the mighty dollar from the pockets of the poor—

Click!

When a water main is leaking in the avenue adjacent, and the company are doubtful whom to saddle with the cost.
I announce to their inspector, with a countenance complacent, that I've swallowed and digested ev'ry gallon that was lost—

Click!

When it happened that the carcass of an infant alligator, plays the mischief with my vitals in its efforts to get through,
I record the strange occurrence on my brass-bound indicator by the fraudulent addition of a hundred feet or two—

C-l-i-c-k!

On the miasmatic matter and the poison which I scatter, by the simple name of water, unadulterated pure!
While my friend, the undertaker, waxes richer, slicker, fatter, and the druggist's wife and daughter take a European tour—

Click!

O, I often pause and wonder as I ponder o'er my plunder, pause and wonder why the thunder honest people let me lie,
Why they do not rise in anger, tear me limb from limb asunder and adopt a water meter more ingenuous than I—

Click!

MISCELLANEOUS BUSINESS.

On motion of Mr. Hawes the thanks of the Association were extended to Chief Engineer Frederick Macy, of the New Bedford Fire Department, for the exhibition which the Department had given for the benefit of the members of the Association.

On motion of Mr. Darling the thanks of the Association were tendered to Messrs. Geo. A. Ellis, Col. J. T. Fanning, Desmond Fitz Gerald, Dexter Brackett and Lucien A. Taylor, for the able and interesting papers which had been presented to the Association.

Mr. Darling. I am not unmindful, Mr. President, of the duties of other committees of this Association, but I desire to call attention to the fact that the committee on the revision of the constitution worked arduously and spent a good deal of time in preparing its report. The committee on information relative to cast iron pipe has reported progress and been given further time. The same with regard to committee on uniform methods of classification of water rates. Now I come to the committee on exchange of sketches, and I wish to say that I think the Association owes a great deal to our friends, Messrs. Sherman and Richards, for what they have produced here. We can get an idea from what we have already seen what will be the result and I hope every Superintendent will use his utmost endeavor in bringing about results which the committee so earnestly and ably have tried to produce. (Applause.)

Adjourned to 7.30 P. M.

EVENING SESSION.

The convention reassembled at 8.05 P. M., President Coggshall in the chair.

Mr. Elbridge T. Brown, Engineer of the Brockton Water Works, having been duly recommended, and approved by the executive committee, was elected an active member of the Association.

The Secretary read a communication from the American Water Works Association inviting the New England Association to be present at their coming convention in Denver, Col.

The Secretary was directed to extend the thanks of the Association to the American Water Works Association for the courteous invitation, and to express regrets that it could not be accepted.

There being no further business, the President invited the attention of the Association to the next topic on the list for discussion, which was,

HOW OFTEN SHOULD MAIN VALVES BE EXAMINED?

Mr. Darling. I have made a practice of examining the main valves twice a year, in the spring and fall. The examination consists of closing the valve and then reopening, oiling and leaving the boxes in good condition.

Mr. Holden. I examine every gate box once in every year, sending a man around to close the gate and then reopen it. I do not know as we ever found a gate leaking until we began to close it. We often find the packing rotten; last year about 30 had to be repacked, although the gates were not leaking at all until we began to shut them down. When repacked they are good for 13 or 14 years, but still we make it a point to examine every year.

Mr. Nevons. I examine my large gates say all above 8-inch, especially gear-gates, twice a year, shutting down and then opening.

Mr. Hyde. I open and close gear-gates, twice a year and my small gates usually once a year.

Mr. Holden. While we are talking about gates, I would like to inquire if anybody has any better preparation for packing than good hemp well tallowed. I find that works well with us, but it will rot out in time. I should like to know if there is anything more durable which will still be tight?

Mr. Chase. I will say that our Engineer uses a compound for saturating hemp composed of tallow, beeswax and plumbago, which gives excellent results, and as far as our experience goes it will last longer than plain tallowed hemp.

Mr. Hyde. I use a packing called the Lyons Packing. It is put up in plumbago and oil. I pack all my gates with it; even when they come to me new I take all the packing out and put that in. I have used it for five years, and I found on examining the gates this year that they were in as good condition apparently as when they were put in. There is no sticking of the spindle.

The President. The next topic is

WHAT IS THE COMPARATIVE VALUE OF WIPED AND CUP JOINTS?

Mr. Billings. I have not very much to say, for I asked the question for the purpose of getting information rather than of giving it. In Boston they have given up the practice of wiping joints, and make their connection between the lead and tail-piece of the corporation by a cup joint. All plumbers, as we know, are inclined to sneer at cup joints, and to say they are only fit for tinkers, but if one uses such a cup joint as is made in Boston, and as we are now trying to make in Taunton, I think there can be no question but that it is equally as good as any wiped joint can be, and Mr. Brackett goes so far as to say it is stronger than a wiped joint and more durable.

The difference between the thorough cup joint of which I speak and the tinker's joint consists mainly in the difference in the depth of the cup and in the method employed in heating the tail-piece and the lead-pipe. The lead-pipe is cupped out about an inch in depth with a cupping-iron, which I will not attempt to describe, although it is very simple, and then the tail-piece, having been previously tinned with good solder, is set into it. It is important that the edge of the tail-piece should be left sharp, not chamferred, so that when the tail-piece is knocked down into the cup the sharp shoulder will cut itself into the lead a little and hold itself there, making it easy to work, and preventing the solder from running down into the lead-pipe. Then a sweating iron, which is nothing but a piece of wrought iron which will fit into the tail-piece, is heated in the forge and put down into the tail-piece at a high temperature, heated red hot. That heats the tail-piece in the lead thoroughly, and then, by putting a little rosin into the space between the lead and the tail piece, and rubbing a stick of solder up and down on the tail-piece, the solder runs around into the annular space or recess evenly, and forces the rosin out, so that it

pours out in a stream over the edge of the cup. That makes a connection an inch long between the tail-piece and the lead, and the tail-piece is buried in solder. How any connection can be firmer, I fail to see.

I have here a sample of the new corporation cock which we use in Taunton, also a sample of a corporation cock which was sent me from McKeesport by Mr. McKim. That is a private company and the cock is very light and very cheap. There is a piece of iron attached to the McKeesport corporation which Mr. McKim told me in his letter, if I am not mistaken, had been in the ground for 25 years, which is, incidentally, an illustration of the durability of galvanized iron pipe in that particular locality. There is also on the platform, with the corporation cock, a T and a piece of cement lined pipe. The T is lined with the composition thimbles, such as Mr. Richards uses in New London, and we use them in Taunton on the tees and couplings.

Mr. Noyes. Some few months ago, in making a call on Supt. Rogers of Lawrence, I saw a very neat method he had of making a cup joint, and I think it would be of interest to the members if he would describe it to us. It may be new to many who are here, it certainly was to me, and it is very ingenious.

Mr. Rogers. Believing the cup joint more economical as well as superior to any other, when properly made, we have taken pains to make special tools to plug out the lead, so as to insure uniformity of size and a perfect fit to the nippers intended to be soldered. We allow them to enter the cup about five-eighths of an inch, with a space for solder varying from one-sixteenth to one thirty-second of an inch. When placed in an upright position and sprinkled with rosin, heat is applied by the use of a gas jet and blow-pipe until the parts are heated so that the solder melts readily when brought in contact. The heat is continued after the joint is full as long as possible without melting the cup. A matter requiring skill on the part the workman. To facilitate the work we draw our solder into the form of wire one-eighth of an inch in diameter. The blow-pipe is operated by a small jet of water discharging into a cylinder past an opening whence it draws in air and holds it sufficiently compressed to give the required force. The time required and the experience of soldering in this way is certainly much less than good work demands with any other method and when the parts to be soldered are treated until the solder fuses when brought in contact, there can be little question of the strength and durability of the joint.

Mr. Hyde. I should like to ask Mr. Rogers if he makes his measurements on the street and carries them to the shop.

Mr. Rogers. We do. With the use of lead we do not make such accurate measurements as with other material.

WATER-HAMMER

The President then introduced the next topic, which was, "State the Largest Recorded Water-Hammer in Your Experience, and the Methods Adopted in Overcoming it," and called upon Mr. Noyes to address the convention.

Mr. Noyes. I hardly anticipated saying anything at this moment. My observations on our own works with regard to water-hammer, have thus

far been comparatively limited. I hope, however, before the end of the year to give it considerable attention, and make some extended observations, particularly in connection with what has been outlined by the committee on cast iron pipe. This very important question is one of those upon which we have but little information, and it is proposed to request of members representing different kinds of works to take extended observations by means of recording guages located on different parts of the works, and to ask that a record of all the conditions be forwarded to the committee. It is thus hoped that a collection of observations will be obtained enabling us to determine a basis of estimate as to the proper allowance to make for water-hammer.

The only real record I have had is a case where the normal pressure was some 20 or 25 pounds, and receded so that the pressure gauge showed no pressure, and then immediately returned to 65 pounds. I reason from the bursting of the service pipes in that case, however, that there have been times when the pressure was very much in excess of that. To overcome it we placed an air valve on the pipe, and we found that the fluctuation of the water in the pipe was such as to create a vacuum, and as a consequenee the air that had been sucked into the pipe formed a cushion, which relieved the pressure very much. There is another way which Mr. Hyde, our Superintendent, adopted, which consisted of placing a regulator, and there was a certain cushion there which relieved it very much. In our correspondence we received a letter from the engineer of the Amsterdam Works, New York, which stated that they had adopted the same method of placing regulators on, and it answered the purpose.

Mr. Hyde. I have no data to show, with the exception of one case on high ground, when pumping with our large engine, with 21 pounds normal pressure at the point referred to, the fluctuations were from 21 to 50 pounds; after stopping the engine the gauge ran back to nothing, and would have continued if the pin had not prevented, immediately there was a recoil and the pressure returned to 70 pounds. In this case an inch service pipe was burst, at one place being ripped open for two feet.

Mr. Billings. I might say on this subject of water-hammer I have made a beginning in some experiments, which at present are very crude and amount to nothing except, perhaps, to impress me with the fact that in attempting to make any estimate as to what water-hammer will probably be, or in attempting to fathom the law which governs it, I have undertaken a pretty large contract. The only thing I have been able to do yet has been to attach a 2-inch pipe, with a 2-inch metre on it, put the meter close to the hydrant at the pumping station, and then stretch out about 150 feet of 2-inch pipe. On the end of it I put a half-inch quick closing gate valve, with a wrench and lever to operate it easily. In looking into the matter, to begin with, I found that in any attempt to study water-ram, the time occupied in closing the valve, in other words, the time occupied in bringing a body of water in motion to a state of rest, was an important factor in the problem. And as the first step to get at something in that direction, I hung a seconds pendulum close beside the quick closing valve, and endeavored in a series of closings to time the closings of the valves by the vibrations of this pendulum, so as to have a number of closings, each occupying one second of

time. The pressure at the hydrant was 55 pounds, and was subject to some variation, as we have direct pumping, but the variation was not excessive. I have no notes with me, and will not attempt to give the pressures which were obtained, with any exactness, but I know that on shutting off the half-inch valve under this pressure of 55 pounds, ten or a dozen times in succession, the hand of the gauge went up to something over 100 pounds each time. The gauge was one which I got from the American Steam Gauge Company, and it had a check valve on to prevent the rapid recoil, and also had on it a maximum hand and I found that the maximum hand registered higher than the ordinary hand. The check valve would not close quickly enough to secure a registration by the ordinary hand of the excessive pressure.

One day when I was away our foreman undertook a little experimenting on his own account. I think he had on an inch and a quarter valve, and he told me that in closing it quite suddenly, with no attempt to mark the time, the maximum hand went up to over 400 pounds, and that frightened him so he didn't try any more. I hope during the coming year to be able to continue my experiments with some success, and possibly may make a beginning in getting at some definite results.

Mr. Hyde. In connection with this topic of water-ram, I should like to ask if any member present has seen an air valve which works automatically, and which will take the air out of a pipe, without closing immediately as the water reaches it. That is something that I have tried to get. I have tried almost everything, but I cannot find anything that will do. If we could find some valve that would do that we would have something which would relieve our high points at all times.

Mr. Chase. I do not think Mr. Hyde will find anything better in the line of an air valve than to make some reasonably large opening in his main so the air bubbles will have a chance to collect, put in a small pet cock, and arrange to waste a moderate amount of water. My attention was called to a contrivance of that sort some years ago, and I have had occasion in the last few years to use something of the same kind. I have placed at the summit a little tap and run a pipe 25 or 30 feet, put on a small pet cock, and allowed as much water to waste as will run through a sixty-fourth of an inch opening. That comes up through the ground on one side of the street, where it does not attract any attention, and one might think it a was a small leak, but if he watched it, he might see the small air bubbles coming up.

Mr. Tidd. I have had occasion to use automatic air cocks in which the valve closed immediately upon the water reaching it. When the valve is once closed it does not open again until some outside pressure is put upon it: but they have always in every case remained open long enough to allow me to fill my mains. For some time after the valve closes small bubbles of air collect at the top of the pipes upon summits, which it is impossible to prevent.

When a considerable amount of air has collected in such places it must necessarily effect the pressure when a strong draught is being made. I have let this air out in some cases by pressing down the valve from the top with a crooked rod. I am now having them made with a compression

screw passing down through the cap and having a T handle like a sidewalk cock. By turning this down with the ordinary service key upon the valve and forcing it from its seat the accumulated air is allowed to escape. With these valves you can fill the pipe for the first time, and by going over the line afterwards and turning down the screws you can easily let out the air. After the air is once out there is no more trouble from that source.

Now in relation to water-hammer, I made some experiments in that direction, or rather attempted to, but was compelled to abandon it by the fact that I could find no pressure gauge that moved quick enough to indicate the hammer without breaking. If a column of water moving with a given velocity in a pipe be brought to a stop by the instant closing of a valve it will give a shock as violent as that of a bar of iron of the same weight, moving with the same velocity. No gauge would register such a shock, but would be broken in the effort. Of course I can understand that it is impossible to close a valve instanter. The force of a blow given by a column of water, under such circumstances, can be computed if you have the length, size of the pipe and the velocity. The formula for computing the impact is the same as we use in gunnery, and will apply here if you can close the valve quick enough.

Mr. Sherman. Mr. Noyes, as a member of the committee on cast iron pipe, has stated that this is one of the important topics which we propose to touch upon in our report, and I would like to say a word at this time to those members present who have Edson recording gauges connected with their works. Some time ago a series of experiments were made by Mr. Weston, the First Assistant Engineer of the Providence Water Works. I had rather not attempt to give the exact figures with reference to them, and as I recollect it now the experiments were not made in a direct line to determine the amount of water-hammer, but that was brought in incidentally. He started with, I think, four or five lines of pipe, the respective lengths of which I cannot recall,—but I think he started with a six-inch pipe, reducing first to two, then to an inch and a half, then to an inch, and I think the termination was an inch pipe, at the end of which he provided different sized orifices to be used in conjuction with it, and by a lever to close instantly, as Mr. Tidd has stated; and he had gauges on the sections of the pipe. The experiments were primarily made to determine the relative pressures. He first started with the inch orifice, that is made the outlet the full size; and he smashed every gauge that he could get that was strong enough, as he supposed, to stand it. My impression is he had to introduce an orifice not over a quarter of an inch before he could get apparatus that would stand it. Of course in actual practice there probably are no fixtures connected with the distributive system where water could be shut off as quickly as has been suggested, except in the line of small services, and the committee's idea of getting data with regard to water-hammer was to apply it to the main pipes, because it is cast iron pipes to which we have reference. In connection with that point I should like to hear the opinions of some of the Superintendents here, based on what their practice has been and what their ideas are, as to how soon, in hands of careless men, perhaps, a 4-inch or a 6-inch hydrant gate could be closed. I would like this as a matter of information for the committee.

Mr. Clark. I am interested in this question, and, although I may not be able to throw any particular light upon it, I should like to state some facts. In Northampton we have a line of 4-inch pipe extending from a 12-inch pipe, at the extremity of which is a hydrant. From this 4-inch pipe there was taken a side pipe to supply locomotives. When it was first used for that purpose, some fourteen years ago, the arrrangement was such that when the locomotive took water there was such a sudden shock on shutting off that it ruptured the 4-inch pipe and deluged the street, The Superintendent at that time ordered the discontinuance of such use. Subsequently one of our Water Commissioners devised an automatic valve that would open very gradually, and could be regulated to open itself by a peculiar construction, and from that time we had no particular difficulty until on one occasion the arrangement of the valve was disordered by some cause, and there was another rupture, and this time it was on the 12-inch pipe a half mile away. The parties then concluded to put in another stand on this short piece of 4-inch pipe, and did so, but still the arrangement was not satisfactory. We put a guage on the fire hydrant at the extremity of this 4-inch pipe, and allowed them to try their new arrangement. The first time threw up the gauge to 220 pounds, and we stopped them.

Mr. Sherman. What was the normal pressure?

Mr. Clark. From 90 to 100 pounds.

Mr. Sherman. I should like to ask Mr. Clark how long the 4-inch pipe was.

Mr. Clark. It was about 500 feet from the 12-inch pipe.

Mr. Sherman. How long was the 12-inch pipe back, before the pipes commenced to spead? I understand this to be a sort of isolated line.

Mr. Clark. The 4-inch was, but the 12-inch is two miles and a half long, and it had branches.

Mr. Sherman. Was the 12-inch pipe broken back of where the pipes commenced to spread out?

Mr. Clark. Yes, sir.

Mr. Tidd. At the Lowell Railroad stand pipe we put on a small wheel so the men could not shut the water off quickly; but they replaced it with a larger wheel, and it broke everything all up so we had to keep men at work there all the time. Finally I closed the main down to about the capacity of a 2-inch pipe, without letting them know anything about it, and they turned it on as fast as they wanted to and were perfectly satisfied. (Laughter.)

Mr. Hall. The committee appointed to make experiments on cast iron pipe have stated that they want some suggestions as to experience with water-hammer. It has occurred to me to ask whether they have yet devised any uniform plan of operation, or whether each one of us is desired to do as he sees fit, or as is most convenient. Perhaps I may illustrate by referring to our works. I have a recording gauge at our pumping station and whenever a hydrant is opened, whether it is near, or a mile or two miles away from it, we can notice a variation on the guage. Now, I would like to ask whether that gauge, for instance, would answer for the experiments on our works, or whether it would be advisable to have records taken at a specified time at different points on the works.

Mr. Sherman. I would state in behalf of the committee that we have made no uniform arrangement as to how the experiments shall be conducted. Personally it is a doubt in my mind whether after we get through conducting the experiments and getting the data, it will be worth anything, because there are so many local circumstances connected with this matter. As I look at it we should attach the gauge directly to the main pipe, and not on any small connection, and then the thing is to get a gauge that will record all the pulsations in that pipe without any wire drawing or throttling down, as Mr. Tidd had to do in order to save his pipe. If we have to resort to throttling down or wire drawing, as the case may be, to save our gauge, then the report the gauge gives is not worth anything; and if we give it full vent, then the question is whether we can get a gauge that can live and tell us what is actually going on in the pipe. With this data which we propose to get from the several Superintendents, it seems to me we also ought to have a complete record or plan of the distribution in the immediate neighborhood of where the gauge is located, and what demands are made; because there are so many local circumstances that may effect it, that it seems to me it will be pretty hard to draw a general conclusion with regard to it.

Mr. Fitz Gerald. There is one question connected with the filling of mains which seems closely allied to this subject, and perhaps it would be a very interesting point to discuss at some future day, and that is the best way of filling large mains, and what the effects sometimes are. I have known times in filling our reservoir, when the recoil has come back with such force as almost to blow the roof off of the gate house. I have not had that personal experience, but I know of its occurring on our water works. When I was in St. Louis I heard of a long main pipe being ruined by the Superintendent allowing the water to be let on with too great velocity; and I made up my mind that whenever I should fill our mains I would do it so as to insure that it would be all right. I have always followed the conservative plan of letting the water in very slowly, although even then I have sometimes had it come back perhaps ten or fifteen feet higher than the reservoir, and overflow the chamber of the gate house. It always seemed to me that we did not have sufficient protection against that kind of thing on our large mains. On the Sudbury River 48-inch pipe, we have built a large chimney which rises about 20 feet above the surface of the ground, and sometimes, when the foreman has not been quite careful enough in letting the water on, the water and air have come out of the top of the chimney. I think it shows the importance of providing, especially on large and important mains, a sufficient vent for the air and for the water-hammer.

Mr. Darling. We have had occasion some five or six times during the past six years, to empty the main pipe, which is a 24-inch main, down as far as the foot of the hill below the reservoir. I have seen that, when we were refilling it, throw the water and air combined, 25 feet high.

Mr. Fitzgerald. Did you let the water on yourself?

Mr. Darling. Yes, sir; and I never let it on to exceed four inches of the gate from the reservoir. I have seen it act in this way, and we always expect it to. I have always contemplated putting a 6-inch pipe from the main below, making a connection with the main and up through the chamber, in order to let the air escape.

Mr. Fitz Gerald. I would like to ask if any gentleman here knows of a main pipe having been split from water being turned on too suddenly.

Mr. Horan. At one time we provided a 4-inch supply for the engines on the railroad. This was controlled by a 4-inch gate and a spindle carried about eight feet high, so that a man could step off the engine to the platform. A wheel about three feet across was put on the end of the spindle. We have two reservoirs, a basin from which we draw our water and distributing reservoir. We were experimenting at this time to get the evaporation of our distributing reservoir, and had it shut off. A day or two after we made this connection, in the night time, somewhere about two or three o'clock, one of the freight engines came up for a supply of water, and when they shut down, a 14-inch pipe at the reservoir was burst the whole length. They said the piece of pipe came right up out of the ground. The reservoir is half a mile away from the depot. The 4-inch pipe connected with a 12-inch pipe which ran along a quarter of a mile, and then connected with a 14-inch, and it was this 14-inch pipe, at the reservoir, where there is little pressure, which burst.

Mr. Rogers. I remember when the water was first let down through the 20-inch pipes from the distributing reservoir in Beverly to the city of Salem, section after section had been successfully filled until we reached a section crossing Bass River, laying level, on a pile bridge about 1200 feet in length including a syphon of thirty-inch pipe under a deep channel at the draw. Water was let in on the Beverly side and the air exhausted through two ¾-inch cocks, one at each side of the syphon, that portion of the section between the filling gate and the syphon which was much the shortest part filled rapidly, whilst indications of water at the air cock beyond the syphon were so faint and the dinner hour so near as to cause impatience on the part of the Engineer in charge, who ordered the filling gate to be opened still more, and finally, at the first appearance of water at the air cock, ordered the gate opened wide, resulting in the total destruction of a length of pipe with a report that could be felt. The presumption is that the water was flowing in so rapidly that when it appeared at the air cock the pipe still lacked several inches of being full at the end, 800 feet distant, and that instead of an order to open wide it should have been to close down to a mere sing and let it remain so, until that singing ceased, when the gate could have been safely raised.

Mr. Fitz Gerald. It seems to me that the question of the compression of air in the pipe is a little different from that which had been considered before I made my suggestion. Of course we know that air is very compressible, and water is not, and that our mains compress and accumulate a vast amount of power, and when the reaction comes, something is bound to give way.

Mr. Noyes. In regard to the arrangement of gauges by which it was hoped a valuable record would be obtained by the committee, I might add a little in explanation, and ask the managers of the various works, especially those who have recording gauges, to keep a careful record of the various fluctuations that they find as their gauges are now placed. In considering the question as to the proper thickness of cast iron pipe, bothMr. Howland and I had great difficulty in obtaining data as to the variations to

which these pipes are subjected in the various works. The correspondence, while it extended over a large number of works, gave us but little information, and it is surprising how little thought and attention has been given it by the various Superintendents. That being one of the initial points in determining what is the safe thing, we hope that this year many observations will be made. The method that I had outlined in my own mind was to place recording gauges at various points on the works, carefully studying their relations one with another, and observing how fluctuations in a certain portion of the works influence other portions. I do not know as that would give us the results we are seeking, but I can see no way in which we can determine anything, except by such data as this. If, in thinking it over, the members of the Association can make any suggestions, the committee will be very glad to receive them.

DRIVEN WELLS.

The President. The next topic for discussion is, "State Your Experience with Driven Wells." Cannot you give some light, Mr. Tidd ?

Mr. Tidd I would like to have somebody else throw some light on this somewhat dark subject. Like all these subterranean matters, there are a great many "ifs" connected with it. I built some works last year at Hyde Park, in this State, where the supply is entirely taken from the driven wells There are 64 2-inch wells along on the banks of the Neponset River, driven from 25 to 38 feet, all of which are connected with horizontal pipes under the ground, and run into one collection chamber, from which the water is pumped. Since last October these wells have furnished the town with all the water necessary. We never tested them but once, and then we pumped on them for seven days at the rate of about 1,000,000 gallons a day, and in so doing our vacuum gauge showed about 15 feet lift on the suction, at the lower line of the water. We found afterwards that when we drew the water down to fifteen feet and waited until the next morning, it returned to its former level, which was about 8 below the gauge on the pump. We found that no amount of pumping at that time would reduce it below the 15 feet.

I am now making some experiments at Cohasset for small water works to obtain a supply in a similar manner. The wells which are now driven are partially experimental.

We have about 30 already in, and have been pumping from them 24 hours per day for six or seven days (I am not quite sure which) and getting at the rate of about 500,000 gallons per day.

The wells are of two inch pipe, and are some distance apart, I think from 20 to 40 feet, but they are all connected with one pump.

We were able to run at velocity which gave us that amount, but when we increased the speed, one or two of the wells gave us air, which came through the line and made its appearance at the pump, producing the well known kick that always indicates its presence.

These wells are to be driven deeper or plugged. I have no doubt we could have obtained more water if they had been tight.

I think that the stratum between them and their supply was more compact than that between them and the pump, thus allowing the water to pass to

the pump faster than the supply came to the wells. We propose to put in about double the present number.

They are two inches in diameter, and from 22 to 23 feet deep. Some go to the bed rock, and some stop at the gravel. We find the water just above the bed rock in the stratum of coarse gravel, and it is very fine.

The President. I believe Mr. Noyes is engaged in some experiments on this question now.

Mr. Noyes. This question has deeply interested me for some years. In examining the problem of a water supply, there are many districts where it is very difficult and sometimes impossible to get streams, or storage basins, or ponds; but we know by observation that there are storage reservoirs beneath the surface, and the amount of water which they will yield is dependent upon the hardness of the stratification below the water table, and the size of the perforations, or the pipe. Of course, as they are hidden, we cannot come to conclusions in regard to them as readily as we can in regard to an open and free basin, and the stratification may go in such ways that it is a very uncertain thing to attempt to make any estimate. My first experience with driven wells was obtained in an attempt to increase our supply. The city of Newton is supplied from a filter basin, as it is called, which is really a well dug down below the water table, and is fed largely from the ground water, or what might be called springs. The banks of this basin are fine gravel or sand, and the slopes are, I think, two and a half to one. The rapid rising and lowering had drawn the finer particles of silt into the bottom, so it had somewhat stopped the free flow of the water. The question was as to the best way to expedite the flow. At the suggestion of Mr. Worthen, who was then in consultation with me on some other matters, we drove pipes into the coarser strata lying beneath the bed of clayey quicksand, and obtained very good results. The water table being at grade 90, and low water in the filter basin being at grade 85, we had nominally a head of about five feet, although that would vary according to the length of time we had drawn water from the basin. These pipes were cut off between 85 and 86, and there was a very substantial flow, which very nearly, if not fully, replaced the original amount that flowed into the basin.

The next experience I had was in making an excavation in a quicksand. for the purpose of drawing down the ground water. I was desirous of working in as dry an excavation as possible, and a series of pipes was driven into the slightly coarser stratification below the quicksand. The pumps were applied to them, and the ground water was drawn down so that my work was practically dry and went on very safely and satisfactorily.

Within the last two years the necessity of increasing our supply has come before the water board, and as a means which might be available, I have recommended the driving of a series of wells near our station. We have found that below this layer of clayey quicksand there is a coarse stratum of 23 or 25 feet of coarse sand and gravel, and then the clayey hard pan, and from that I believe we shall get a very considerable flow of water. Our experiments so far have indicated it. We have driven two, two and a half, and eight inch pipes. The two and two and a half inch pipes have been perforated, with open ends, and have been cleaned out with a sand pump or water jet, which has forced the finer particles out. At present we are adopt-

ing a little different method. We have contracted with the managers of the Artesian Well Co. of New York, and they are driving an 8-inch pipe. After determining the proper depth of perforation, they inserted a slotted 6-inch pipe. The slots are of the depth that the coarse stratification would indicate to be proper. The 8-inch pipe is withdrawn, the finer particles settle closely around the pipe, leaving the bottom well open, and the slotting in the pipe in a perfect condition. We have inserted in the 8-inch pipe a 4-inch pipe, and from that we propose to draft. The theory is that the drafting upon the outside pipe is apt to disturb the finer particles during the pumping. Whether that will prove as satisfactory in its practical working, as it seems to be theoretically, I cannot say.

The question has been brought up whether the pipes will not gradually fill up. I find that opinion differs very largely upon this. Mr. Worthen has given considerable attention to this matter, and is very sanguine as to the success of the method as a means of supply for many places. He has investigated in Germany, where the system has been practiced for the longest period of time, I think, and their conclusions are that the pipes do gradually fill up, and that they have to be pulled up and driven in a slightly different location. But the experience in this country, so far as I can find from talking with old well drivers, and with persons who have used the wells, is that the supply has constantly increased. It is some three or four years since these pipes were driven in the filter basin, and I do not see but that they flow just as freely as they did the day they were driven, and there has been no tube put into them to clean them out.

On motion of Mr. Darling the topic "What is the best Method of Lining wrought Iron Service Pipe ?" was passed.

CONCLUDING EXERCISES.

On motion of Mr. Darling the arrangements for the September meeting were left with the executive committee.

On motion of Mr. Darling the President was instructed to appoint a committee of three to take into consideration the question of furnishing badges for members. The President appointed Messrs. Rogers, Darling and Glover.

Mr. Billings. There is one more motion which it is my pleasure to offer, and which it would be the pleasure of any one here to offer. I have heard it expressed in more ways than one, to-day and yesterday, by various members of the Association, that we have had a most interesting convention. Much of that interest and pleasure I am sure is due to the hearty and cordial welcome we have received from New Bedford. I therefore move you, sir, that the thanks of this Association be tendered to the New Bedford Water Board and all of their subordinates for what they have done to make our stay here so pleasant. The motion was adopted by a rising vote.

President Coggeshall. Gentlemen, I heartily thank you for your co-operation during the past year. It has been an exceedingly pleasant year to me, and I trust my service may have been as acceptable to you, as it has been a pleasure to me. One pleasant duty remains for me to perform, and that is to present to you your President elect, Henry W. Rogers of Lawrence. (Applause.)

President Rogers. Gentlemen, I feel deeply sensible of the honor which your placing me in this position was intended to confer, and also of the obligation which it places me under to you. I am well aware of my shortcomings, and shall have to ask your indulgence many times, probably. However, with your co-operation, which I feel sure of, we will try to do our best. (Applause.)

On motion of Mr. Coggeshall the convention then dissolved.

FRIDAY MORNING—THE LAST DAY.

The members seemed even more interested in the subject of "rainfall" Friday morning than when Mr. Fitz Gerald read his admirable paper on that subject at the session the day previous. A programme had been mapped out for their entertainment on this the closing day of the convention, in which the weather was an important factor and many anxious looks were cast skyward.

The members of the convention met at 8 o'clock at the office of the Water Board, City Hall, and with Mayor Rotch, President Wood of the Common Council, ex-Mayor Wilson, the members of the Water Board, Alderman Cobb, and Councilman Church took carriages for a drive through the city. A visit was made to the Distributing Reservoir, and the weir, over which was flowing water from the pumps of the Worthington engine, was inspected. Mr. Coggeshall explained the manner of measuring the volume of water flowing over the weir and the means of communication between this point and the engine house by private telegraph.

Then the party visited the pumping station, where the new Worthington "high duty" engine was in operation. W. J. Root, chief engineer of the Worthington works, and A. J. Caldwell of the Worthington company, did the honors for the firm which they represented, and explained the new engine to the visitors. The old Worthington was also at work pumping through the old force main, which leads to the bottom of the gate house at the distributing reservoir.

Soon after arrival at the pump-house, the train which left Boston at 8.30 stopped in front of the building, and about twenty gentlemen alighted and joined the party. The new engine was the principal source of attraction. Mr. Root then invited the company to a lunch which was served under a tent pitched upon a lawn at the rear of the station. The tables were handsomely set and decorated with flowers. Salads, cold meats, ices and fruits were served. At this point Mr. Billings of Taunton, in behalf of the Association, presented Mr. Glover, the Secretary, with an envelope containing a sum of money, the gift of the active members or the Association as a recognition of his services as Secretary. At the Pumping Station a large number of citizens joined the party and a half hour was then spent about the works and the neatness of the ground, with its closely cut lawns and flower spots was very generally admired. A special train then conveyed the party to Steamboat Wharf, where steamer Martha's Vineyard was ready to take the party for a sail down the bay. Hill's Band accompanied the excursion and its selections were warmly applauded.

The serious work of the Convention was now over and the members and guests made a merry party.

Meanwhile the boat had skirted the shores of Nonquitt and round Wilkes Ledge buoy, till they could feel a little of old ocean rolling in, went eastward about two miles beyond West's Island, and returned to the harbor.

As she was passing West's Island to the eastward the visitors were called to the main deck, where a nice collation was served.

A short meeting of the Association was held in the upper saloon as the steamer, neared the wharf, and votes of thanks with all the usual adjectives, were passed to H. R. Worthington and the City of New Bedford, for the entertainment of the day.

At the wharf the train was waiting to receive the party, and most of them left for Boston.

The following were present during the Convention :

ACTIVE MEMBERS.

Willard Kent, Superintendent, Woonsocket, R. I.
Edwin Darling, Superintendent, Pawtucket, R. I.
Horace G. Holden, Superintendent, Lowell, Mass.
H. L. Schleiter, Superintendent, Meriden, Conn.
John C. Chase, Superintendent, Wilmington, N. C.
Robert C. P. Coggeshall, Superintendent, New Bedford.
R. M. Gow, Superintendent, Medford.
Albert S. Glover, Registrar, Newton.
H. W. Rogers, Superintendent, Lawrence.
James H. Hathaway, Registrar, New Bedford.
S. E. Grannis, Superintendent, New Haven.
J. C. Broatch, Superintendent, Middletown, Conn.
N. Dennitt, Superintendent, Somerville,
William M. Hawes, Commissioner, Fall River.
H. B. Winship, Engineer, Troy, N. Y.
E. A. Wood, Assistant Secretary, West Newton, Mass.
Joseph E. Beals, Superintendent, Middleboro.
Albert F. Noyes, City Engineer, Newton.
W. H. Richards, Superintendent, New London.
J. C. Hancock, Superintendent, Springfield.
Jonas M. Clark, Superintendent, Northampton.
William F. Codd, Superintendent, Nantucket.
William B. Sherman, Engineer, Providence.
Addison Lane, Superintendent, Melrose.
William R. Billings, Superintendent, Taunton.
A. G. Pease, Superintendent, Spencer, Mass.
A. H. Howland, Engineer, Boston.
Patrick Keirnan, Superintendent, Fall River.
F. H. Parker, Superintendent, Burlington, Vt.
Edward W. Cate, Commissioner, Newton, Mass.
George A. Stacy, Superintendent, Marlboro, Mass.
Phineas Ball, Engineer, Worcester, Mass.
A. E. Martin, Superintendent, South Framingham.
Hiram Nevons, Superintendent, Cambridge.
William S. Barbour, City Engineer, Cambridge.
F. F. Forbes, Superintendent, Brookline, Mass.

Benjamin S. Grush, Superintendent, Salem.
M. M. Tidd, Hydraulic Engineer. Boston.
David W. Horan, Superintendent, Clinton, Mass.
George E. Batchelder, Registrar, Worcester.
Frank E. Hall, Superintendent, Quincy.
Desmond Fitz Gerald, Superintendent, W. Div. Boston.
George E. Winslow, Superintendent, Waltham.
M. Mason, Superintendent, St. Albans, Vt.
Dexter Brackett, Assistant City Engineer.
H. N. Hyde, Jr., Superintendent, Newton.
Albert B. Drake, Engineer, New Bedford.
B. F. Drake, Superintendent, Laconia and Lake Village, N. H.
R. R. Yates, Superintendent, Northboro, Mass.
J. W. Morse, Superintendent, Natick.
Wilbur F. Learned, Resident Engineer, Ashland Basins, Boston Water Works.
J. Henry Brown, Superintendent Mystic Division, Boston Water Works.
W. C. Wilcox, ex-Water Registrar, Waltham, Mass.
John H. Perkins, Superintendent, Watertown, Mass.
E. H. Phipps, Supt. West Haven Water Co., New Haven, Conn.
William Rotch, Civil Engineer, Boston, Mass.
William Hancock, Commissioner, Trenton, N. J.
E. L. Brown, City Engineer, Brockton, Mass.
W. S. Chaplin, Professor Engineering, Harvard University, Cambridge, Mass.
Frank L. Fuller, Engineer, Welesley Hills, Mass.
David B. Kempton, Commissioner, New Bedford, Mass.
Geo. H. Bishop, Civil Engineer, Middletown, Conn.

ASSOCIATE MEMBERS.

John C. Kelley, National Meter Co., New York.
Charles H. Baldwin National Meter Co., Boston.
Jason Giles, Chapman Valve Co., Indian Orchard, Mass.
W. D. Fiske, Knowles Steam Pump Co., Boston.
F. W. Seaver, Chapman Valve Co., Springfield.
Randolph Brandt, Selden Patent Packing, New York.
A. H. Brodrick, Chadwick Lead Works, Boston.
William A. Brown, Deane Steam Pump Co., Holyoke.
Jesse Garrett, R. D. Wood & Co., Philadelphia.
B. Frank Polsey, Walworth Manufacturing Co., Boston.
W. J. Root, Engineer for Henry R. Worthington.
W. H. Marsh, Tuerk Motor Company, New York.
John Andrews, Abestos Packing Company, Boston.
E. P. Draper, Patee & Draper, Holyoke.
Edward H. Rice, Walworth Manufacturing Co., Boston.
A. F. Upton, Jarvis Eng. Co., Boston, Mass.
John Cunningham, Cunningham Iron Works, Boston, Mass.
M. T. Davidson, Davidson Steam Pump Works, Brooklyn, N. Y.
John T. Langford, Contractor, Boston, Mass.
B. C. Mudge, H. G. H. Tarr and S. E. Welch, of H. R. Worthington Co.

J. A. Tilden, Hersey Meter Company, South Boston, Mass.
W. H. Foster of the Whittier Machine Co.

HONORARY.

George H. Frost, Engineering News, New York.

GUESTS.

F. A. Denson, Commissioner, Newton, Mass.
D. N. Sweitser, President, Lynn, Mass.
A. A. Davis. Commissioner, Lynn, Mass.
A. J. Jones, Superintendent, New Brunswick, N. J.
H. Q. Sanderson, Commissioner, Springfield, Mass.
F. B. Bickford, Superintendent O. C. R. R. Water Works, Boston, Mass.
George Pettie, Commissioner, Newton, Mass.
Geo. A. Kimball, City Engineer, Somerville, Mass.
Joseph E. Watt, Commissioner, Lawrence, Mass.
A. H. Smith, President ; Wm. Leonard, Commissioner ; D. B. Gardner, Chas. Higbee, Salem, Mass.
James P. Roberts, Pumping Engineer, Lowell, Mass.
P. I. Perrin, Commissioner ; Henry M. Lovering, Commissioner ; S. D. Presbrey, M. D., Commissioner, Taunton, Mass.
Robert D. S. Mortimer, Commissioner ; James I. Murphy, Commissioner, Marlboro, Mass.
Weaver Osborne, Commissioner ; Joseph Waters, Commissioner, Fall River, Mass.
Wm. B. Smart, Commissioner ; Thos. F. Doherty, Commissioner ; Wm. Jackson, City Engineer, Boston, Mass.
Mayor Whipple, Brockton.
Col. I. F. Kingsbury, City Clerk, Newton.
Mayor Kimball, Newton.
President French, of Common Council, Newton.
W. F. Cleveland, Supt. Water Works, Brockton.
Mayor Hart of Lynn.
Ex-Mayor Fuller of Malden.
Milo Crane, Somerville Water Board:
A. P. Leshure, Chief Engineer of Fire Dept., Springfield, Mass.
Mayor Greene of Fall River.
Mayor Rotch of New Bedford.
Messrs. Church, Wood and Howard, of the New Bedford Water Board.
Aldermen Pierce, Brownell and Dawson, Councilmen Brown, Case, Dugan, Gifford, Snow, Gomley, Hicks, Janson, Kelleber, Leverett, Peirce, Reed, Russell, Swift, Tuell and Washburn ; Ex-Mayors Richmond, A. H. Howland, Jr., and Soule ; Col. J. A. P. Allen, Collector of Customs ; Representatives Cook and Godfrey ; Messrs. Matthews, Tompkins and Washburn of the School Committee ; Mr. Harrington, Superintendent of Schools, the firemen called out Thursday ; Chief of Police Tompkins ; City Messenger Piper ; Gen. J. D. Thompson and Mr. R. W. Taber of the Board of Health ; Daniel B. Leonard, Esq., City Clerk, Rufus A. Soule ; Frederick S. Allen, William Gordon, Jr., Pardon Cornell, George R. Stetson, John A. Bates, Henry J. Taylor, Thomas Bennett, Jr., Charles S.

Randall, Charles H. Leonard, and Dr. C. L. Swasey; Mr. Benjamin. Vice Chairman of the School Committee, President Ladd of the New Bedford & Fairhaven Street Railway, Supt. Kent of the Grinnell Mill, City Auditor Topham, D. D. Briggs, Assistant Superintendent of the Fire Alarm Telegraph; N. H. Greene, Superintendent of Streets, and many others. The total number, outside of citizens, was about 150.

All correspondence relating to advertisements should be addressed to the Secretary at West Newton, Mass., while that relating to all other matter for publication should be sent to the Senior Editor at New Bedford, Mass.

Our fellow member, Mr. Lucian A. Taylor, has been engaged during the season upon an important, interesting and difficult piece of sewer construction in the city of Lynn, Mass. The cuts in some sections were fifty feet in depth, and tunnelling was found expedient. The quantity of water to be handled daily was upward of 3 million gallons,

Since the June meeting a new meter has been brought to the notice of your Editors. We offer no opinion as to its merits, but can freely say that for novelty and ingenuity it must certainly take a prominent place. Its principle is such that it must be placed in the attic of a house, and the water passing through it must be delivered into an open tank. The meter will detect the smallest possible leak, because no attempt at measment is made until enough water has been drawn from the tank to cause the meter to run at, or nearly at, full speed.

Membership Roll.

ACTIVE MEMBERS.

Allen, Charles A., City Engineer, Worcester, Mass.
Allen, Charles F., Treasurer, Hyde Park, Mass.

Babcock, Benjamin S., Superintendent, Nashua, N. H.
Ball, Phinehas, Civil Engineer, Worcester, Mass.
Bagnell, R. W., Superintendent, Plymouth, Mass.
Barbour, Wm. S., City Engineer, Cambridge, Mass.
Brown, Edward H., Secretary, Treasurer and Superintendent, Syracuse, N. Y.
Barney, W. H., Superintendent, Milford, Mass.
Bickford, N. B., Superintendent Water Dept. O. C. R. R., Boston, Mass.
Batchelder, George E., Registrar, Worcester, Mass.
Brush, Charles B., Engineer and Superintendent, Hackensack Water Co., Hoboken, N. J.
Battles, James M., Lowell, Mass.
Bishop, G. H., Civil Engineer, Middletown, Ct.
Billings, William R., Superintendent, Taunton, Mass.
Brackett, Dexter, Assistant City Engineer, Boston, Mass.
Brady, Thomas H., New Britain, Ct.
Babcock, S. E., Chief Engineer of Construction, Little Falls, N. Y.
Brand, Junius A., Superintendent, Norwich, Ct.
Brinsmade, Daniel S., Civil Engineer, Birmingham, Ct.
Beals, Joseph E., Clerk and Registrar, Middleboro, Mass.
Broatch, J. C., Superintendent, Middletown, Ct.
Brady, John B., Commissioner, Worcester, Mass.
Brown, J. Henry, Superintendent Mystic Division, Boston, Mass.
Brown, Elbridge T., City Engineer, Brockton, Mass.

Caldwell, Joseph H., Registrar Mystic Division, Boston, Mass.
Cate, E. W., Water Commissioner, Newton, Mass.
Chadbourne, E. J., Superintendent of Construction, Haverhill, Mass.
Chase, John C., Superintendent, Wilmington, N. C.
Chaplin, W. S., Professor of Engineering, Harvard University, Cambridge, Mass.
Clark, Jonas M., Superintendent, Northampton, Mass.
Cochran, Robert L., Superintendent, Nahant, Mass.
Codd, William F., Superintendent, Nantucket, Mass.
Coburn, Walter, President, Lowell, Mass.
Coggeshall, R. C. P., Superintendent, New Bedford, Mass.
Coryell, Martin, Engineer and Superintendent, Lambertville, N. J.
Crehore, Dr. C. F., Commissioner Newton, Mass.
Cutts, Hiram, Office Water Registrar, Boston, Mass.

Darling, Edwin, Superintendent, Pawtucket, R. I.
Davis, H. F., Superintendent, Athol, Mass.
Decker, J. H., Superintendent, Hannibal, Mo.
Diven, J. M., Secretary and Treasurer, Elmira, N. Y.
Dennett, Nathaniel, Superintendent, Somerville, Mass.
Dewson, F. A., Commissioner, Newton, Mass.
Denman, A. N., Secretary and Treasurer, DesMoine, Iowa.
Dotten, William T., Superintendent, Winchester, Mass.
Drake, Albert B., City Surveyor, New Bedford, Mass.
Drake, B. Frank, Superintendent, Lake Village, N. H.
Dixon, William, Superintendent, Mt. Pleasant, Mich.

Ellis, George A., Constructing Engineer, Racine, Wis.

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Fitts, A. B., Registrar, Attleboro, Mass.
Fitz Gerald, Desmond, Superintendent, Western Division, Boston, Mass.
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Forbes, F. F., Superintendent, Brookline, Mass.
Fteley, Alphonse, Executive Engineer New Croton Aqueduct, New York, N. Y.
Fuller, Frank L., Engineer, Wellesley Hills, Mass.

Gardner, L. H., Superintendent, New Orleans, La.
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Hancock, Joseph C., Superintendent, Springfield, Mass.
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Harding, Walter H., Registrar, Cambridge, Mass.
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Hathaway, J. H., Registrar, New Bedford, Mass.
Hawkes, Ward W., Superintendent, Malden, Mass.
Hawes, Wm. M., Commissioner, Fall River, Mass.
Heald, Simpson C., Hydraulic Engineer, Worcester, Mass.
Hancock, William, President Water Board, Trenton, N. J.
Hildreth, Milo, Registrar, Northboro, Mass.
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Horan, David W., Superintendent, Clinton, Mass.
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Kempton, David B,. Commissioner, New Bedford, Mass.
Knapp, Horace H., Clerk, Lowell, Mass.
Kieran, Patrick, Superintendent, Fall River, Mass.

Lane, Addison, Superintendent, Melrose, Mass.
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Lovell, Thomas C,, Superintendent, Fitchburg, Mass.
Lyons, James W., Superintendent, Racine, Wis.

Martin, A. E. Superintendent, Framingham, Mass.
Martine, A. H., Superintendent, Knoxville, Tenn.
Mason, Marshall, Superintendent, St. Albans, Vt.
Miles, Alvoid O., Providence, R. I.
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Morse, James W., Superintendent, Natick, Mass.
Murdoch, Gilbert, Superintendent, St. Johns, N. B.

Nevons, Hiram, Superintendent, Cambridge, Mass.
Northend, C. A., Secretary, New Britain, Ct.
Noyes, Albert F., City Engineer, Newton, Mass.
Nason, William E., Superintendent, Franklin, Mass.
Nettleton, C. H. Agent and Superintendent, Birmingham, Ct.

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Perkins, John H., Superintendent, Watertown, Mass.
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Pease, A. G., Superintendent, Spencer, Mass.
Porter, James, Superintendent, Greenfield, Mass.
Phipps, Edward H., Superintendent West Haven Water Co., New Haven, Ct.

Reed, Josiah, Commissioner, Weymouth, Mass.
Richards, W. H., Superintendent, New London, Ct.
Ries, George J., Superintendent, East Weymouth, Mass.
Rotch, William, Civil Engineer, 8 Exchange Place, Boston.
Rogers, Henry W., Superintendent, Lawrence, Mass.
Russell, Daniel, Clerk, Everett, Mass.
Ryle, William, Superintendent, Patterson, N. J.

Schleiter, Henry L., Superintendent, Meriden, Ct.
Seymour, C. W. S., Superintendent, Hingham, Mass.
Sherman, William B., Mechanical Engineer, Providence, R. I.
Sprague, Phineas, Registrar, Malden, Mass.
Stacy, George A., Superintendent, Marlboro, Mass.
Stanhope, H. R,, Superintendent of Construction, Springfield, Mass.

Taylor, Lucian A., Civil Engineer, Worcester, Mass.
Tenney, Jos. G., Superintendent, Leominster, Mass.
Tidd, M. M. Hydraulic Engineer, Boston, Mass.

Walker, Charles K., Superintendent, Manchester, N. H.
Whidden, Hosea F., Commissioner, South Abington, Mass.
Whitlock, Frank W., Assistant City Engineer, Waterbury, Ct.
Wilcox, Wm. C., Waltham, Mass.
Wild, George E., Superintendent, South Weymouth, Mass.
Whitcomb, W. H., President Water Co. Norway, Me.
Wescott, George P., Treasurer Water Co., Portland, Me.
Winship, Horace B., Civil Engineer, Troy, N. Y.
Wigal, J. P., Superintendent, Henderson, Ky.
Winslow. George E., Superintendent, Waltham, Mass.
Wilson, James, Manager and Engineer, Kingston, Can.
Whittemore, W. P., Superintendent, North Attleboro, Mass.

Yates, Richard R., Superintendent, Northboro', Mass.

HONORARY MEMBER.

Frost, George H., Editor Engineering News, New York City, N. Y.

ASSOCIATE MEMBERS.

Asbestos Packing Co., 169 Congress street, Boston.
Ashton Valve Co., 271 Franklin street, Boston, Mass.

Blake, George F., Mfg. Co., 44 Washington street, Boston, Mass.
Boston Lead Mfg. Co., 162 Congress street, Boston, Mass.
Brandt, Randolph, 38 Cortlandt street, New York.

Chadwick Lead Works, 171 High street, Boston, Mass.
Chapman Valve Co., Indian Orchard, Mass.
Cunningham Iron Works, 109 Milk street, Boston, Mass.
Curley, Thomas, (Ward & Curley) 140 Oliver street, Boston, Mass.
Curtis Regulator Co., 59 Beverly street, Boston, Mass.
Coffin Valve Co., 295 South street, Boston, Mass.

Davidson Steam Pump Co., 77 Liberty street, N. Y.
Deane Steam Pump Co., Holyoke, Mass.

Equitable Water Meter Co., 36 India Wharf, Boston, Mass.

Ferguson, George B.. (H. R. Worthington Co.,) 86 Liberty street, N. Y.
Fiske, Wilbur D., (Knowles Steam Pump Co.,) 44 Washington street, Boston, Mass.
Franklin, Albert B., 30 Charlestown street, Boston, Mass,
Frost & Adams, 37 Cornhill, Boston, Mass.

Gallison, W. H., 42 Oliver street, Boston, Mass.
Giles, Jason, (Chapman Valve Co.) Indian Orchard, Mass.
Gowing, E. H. (H. R. Worthington Co.) 70 Kilby street, Boston, Mass.

Hartford Meter Co., 336 Asylum street, Hartford, Ct.

Jarvis Engineering Co., 61 Oliver street, Boston, Mass.
Jenkins Bros., 79 Kilby street, Boston, Mass.
Jenks, Henry F., Pawtucket, R. I.

Langford, John T , 70 Kilby street, Boston, Mass.
Ludlow Valve Mfg. Co., Troy. New York.

McClallan, W. C., Contractor, U. S. Hotel, Boston, Mass.
Marsh, W. H., Tuerk Motor Co., 12 Cortlandt street, New York.
Morton, A. M., 25 Washington street, Boston, Mass.
Mudge, B. C. (H. R. Worthington Co.) 70 Kilby street, Boston, Mass.

National Meter Co., 252 Broadway, New York.
National Tube Works Co., McKeesport, Pa.
Newman, J. J. & Co., 19 Wilson street, Providence, R. I.

Pattee & Draper, Holyoke, Mass,
Peet Valve, Co. 163 Albany street, Boston, Mass.
Phipps, D. Goffe, New Haven, Ct.

Root, W. J., (Hydraulic Engineer, H. R. Worthington, 86 Liberty street, N. Y.

Sampson, George H., 231 State street, Boston, Mass.
Spooner, D. Brainard, Sears Building, Boston, Mass.
Sumner & Goodwin, 19 Oliver street, Boston, Mass.

Tilden, J. A., (Hersey Meter Co.) South Boston, Mass.
Tarr, H. G. H., Civil Engineer, (H. R. Worthington Co.) 86 Liberty street, New York.

Union Water Meter Co., 31 Hermon street, Worcester, Mass.

Waldo Bros., 88 Water street, Boston, Mass.
Walworth Mfg. Co., 16 Oliver street, Boston, Mass.
Ward, W. H. (Ward & Curley) 140 Oliver street, Boston.
Wood, R. D. & Co., 400 Chestnut street, Philadelphia, Pa.
Woodman, George & Co., 41 Pearl street, Boston. Mass.
Whittier Machine Co., Boston, Mass.
Worthington, H. R., 86 Liberty street, New York.

A. H. HOWLAND,

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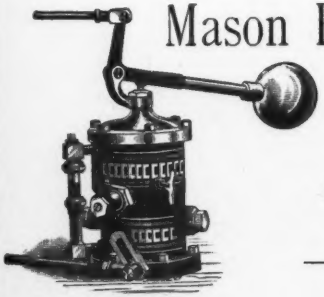
SPECIALTY

Water Works Construction.

OFFICE,

United States Hotel,

BOSTON, MASS.



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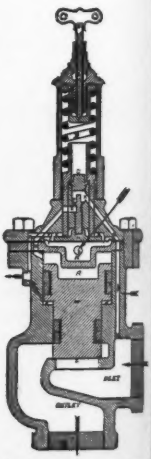

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Pressure Regulators,

Reducing Valves, Balanced Valves, Steam Traps.

Used by the leading Water Works and Pump Manufacturers.

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Correction.

We desire to call attention to an obvious misspelling in the advertisement of Mr. Randolph Brandt, and to an error in the advertisement of the National Meter Co., both of which appeared in our last issue. The office of the company is at 252, not 292, Broadway. For both of the errors and the correction, the Junior Editor is alone responsible.